TWELFTH ANNUAL REPORT

OF THE

CORNELL UNIVERSITY

AGRICULTURAL EXPERIMENT STATION

FOR THE YEAR

1899.

ITHACA, N. Y.

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CORNELL UNIVERSITY

Agricultural Experiment Station,

ITHACA, N. Y.

1899.

THIS REPORT IS NOT FOR GENERAL DISTRIBUTION.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1899

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A. R. WARD, Dairy Bacteriology.
L. ANDERSON, Dairy Husbandry.

OFFICERS OF THE STATION

I. P. ROBERTS, Director.
E. L. WILLIAMS, Treasurer.
EDWARD A. BUTLER, Clerk.

Office of Director, Room 20, Morrill Hall.

The regular bulletins of the Station are sent free to all who request them

ITHACA, N. Y., August 14, '99.

To His Excellency, the Secretary of the Treasury,
Washington, D. C.

To His Excellency, the Secretary of Agriculture,
Washington, D. C.

To His Excellency, the Governor of the State of New York,
Albany, N. Y.

To His Excellency, the Commissioner of Agriculture,
of the State of New York; Albany, N. Y.

SIR :—

I have the honor to transmit herewith the twelfth annual report of the Agricultural Experiment Station of Cornell University, in accordance with an Act of Congress of March 2, 1887, establishing the Station.

This document contains the report of the Director and the special reports of his scientific coadjutors, as well as copies of the bulletins published by the Station during the year, and a detailed statement of the receipts and expenditures.

The Experiment Station of Cornell University is supported by an annual appropriation from the Federal treasury, and its influence has, in recent years, been greatly augmented by reason of supplementary appropriations made by the Legislature of the State of New York. I am convinced that the above appropriations have been wisely expended and that they have already greatly promoted the agricultural welfare of the State.

I have the honor to be your obedient servant.

T. F. CRANE,
Acting President of Cornell University.

REPORT OF THE DIRECTOR.

To the President of Cornell University.

SIR:

I have the honor to transmit herewith the Twelfth Annual Report of the Agricultural Experiment Station of Cornell University. The work of the Station has been broadened and intensified in many ways during the year. The influence of the Station and allied work along agricultural lines is reaching, as never before, the teachers in the schools, their pupils, and especially the young farmers of the state. The appreciation of the efforts which are being made to place agriculture on a more rational basis is marked and gratifying. No longer are the results reached by the Experiment Station unjustly criticised. The farmers are now in a receptive mood and many of them are adopting methods suggested by reading the bulletins. One correspondent who owns a large farm says, "Your bulletins are highly prized as they give most valuable suggestions." Another says, "When I was at Cornell, many years ago, agriculture had no charms for me, now, I would gladly exchange some of my living and dead languages, mathematics, etc., for a knowledge of dairying and small fruits." One farmer writes, "You advised me with regard to soiling. I have had greater success than you promised me." And still another says, "I have adopted the Cornell method of raising potatoes and the yield has more than doubled." These and many similar communications show how eager the farmers of New York are for assistance, and that they look to the Experiment Station and the College of Agriculture for help and guidance.

The Station and College are so intimately connected in the work of imparting and disseminating information related to rural pursuits that it is impossible to write of one without saying something of the other. The College of Agriculture had some difficulty in the early years of its existence in persuading the farmers to read the bulletins and to adopt the practices

which the experiments indicated were the best. To overcome this the Experiment Station staff decided to meet the people at Farmers' Institutes, and other public gatherings, with the view of popularizing the work, and also to give more extended and minute instruction than could be set forth in the bulletins which, of necessity, must be brief. The results of the investigations for economical reasons, had to be presented in a concentrated form, and little attempt was made to explain how the facts reached could best be dovetailed into ordimary farm practice. The farmer, unused to this class of literature, was slow to digest it. It was also found that the audiences addressed were largely composed of those who had passed the youthful period of life when courage, hope and vigor are at their best. However clearly they might see and understand, they often lacked flexibility and hence could not well adapt themselves to new conditions. At last it was perceived that in order to do the greatest good we must reach the children and the young people, and also make use of those who had spent longer or shorter periods of time at the college. This extension work is carried on under three distinct heads—Nature-study, Farmers' Reading Course and Junior Naturalists' Clubs. As soon as this work began, a marked and more intelligent interest was shown in the work of the Station. While this added interest may be simply a coincidence, we are persuaded that it is due, in part at least, to the work which has been carried on under the special lines noted above, and which for brevity is called generically "University Extension."

Since the Extension work of the college has materially assisted the Station in interesting the rural population in the investigations carried on at the University, I have thought best to incorporate with this report the leaflets published during the year and all of the Farmers' Reading Course lessons issued to date. Other circulars of a similar nature have been issued but they do not bear as directly upon the Station work as do those mentioned above, and hence are not incorporated in this report.

A detailed statement of receipts and expenditures for the fiscal year ending June 30th, 1899, the Treasurer's report, and reports

of the heads of the various divisons of the Station, together with an appendix of twenty-one bulletins, are submitted.

The funds appropriated to the College of Agriculture by the State under Chapter 67 of the Laws of 1898, "making an appropriation for the promotion of agriculture by the College of Agriculture of Cornell University," were expended about equally for University Extension Work and for conducting experiments throughout the State. The results of these investigations together with those carried on at the University are in part set forth in the bulletins submitted.

No. 150, "Tuberculosis in Cattle and Its Control."
No. 151, "Gravity or Dilution Separators."
No. 152, "Studies in Milk Secretion."
No. 153, "Impressions of our Fruit-Growing Industries."
No. 154, "Tables for Computing Rations for Farm Animals."
No. 155, "San José Scale; with Remarks on the Effect of Kerosene on Foliage."
No. 156, "Third Report on Potato Culture."
No. 157, "The Grape-Vine Flea Beetle."
No. 158, "Source of Gas and Taint-Producing Bacteria in Cheese Curd."
No. 159, "An Effort to Help the Farmer."
No. 160, "Hints on Rural School Grounds."
No. 161, "Annual Flowers."
No. 162, "The Period of Gestation in Cows."
No. 163, "Three Important Fungous Diseases of the Sugar Beet."
No. 164, "Peach Leaf Curl and Shot-hole Fungous."
No. 165, "Ropiness in Milk and Cream."
No. 166, "Sugar Beet Investigations for 1898."
No. 167, "Construction of the Stave Silo."
No. 168, "Studies and Illustrations of Mushrooms; II."
No. 169, "Studies in Milk Secretion."
No. 170, "Emergency Report on the Forest-Tent Caterpillar."

TEACHERS' LEAFLETS ON NATURE-STUDY.

No. 12, "How the Trees Look in Winter."
No. 13, "Evergreens and How They Shed their Leaves."

NATURE-STUDY BULLETINS.

No. 1, "Nature-Study."

READING-COURSE FOR FARMERS.

No. 1, "The Soil; What it is."
No. 2, "Tillage and Under-drainage; Reasons why."
No. 3, "Fertility of the Soil and What it is."
No. 4, "How the Plant Gets Its Food from the Soil."
No. 5, "How the Plant Gets Its Food from the Air."

Very respectfully submitted,

I. P. ROBERTS.

Director.

REPORT OF THE TREASURER.

The Cornell University Agricultural Experiment Station,
In account with
The United States Appropriation, 1898–9.

	Cr.	Dr.
To Receipts from the Treasurer of the United States as per appropriation for fiscal year ending June 30, 1899, as per Act of Congress approved March 2, 1887:		$13,500 00
By Salaries	$9,106 65	
Labor	1,109 11	
Publications	1,782 32	
Postage and stationery	270 34	
Freight and express	43 49	
Heat, light, and water	48 89	
Chemical supplies	86 62	
Seeds, plants, and sundry supplies	455 72	
Fertilizers		
Feeding Stuffs	92 16	
Library	77 76	
Tools, implements, and machinery	17 95	
Furniture and fixtures	4 00	
Scientific apparatus	119 28	
Live stock	7 50	
Traveling expenses	120 99	
Contingent expenses	10 00	
Building and repairs	147 22	
Balance		
Total		$13,500 co

We, the undersigned, duly appointed Auditors of the Corporation, do hereby certify that we have examined the books and accounts of the Cornell University Agricultural Experiment Station for the fiscal year ending June 30, 1899; that we have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been $13,500.00 and the corresponding disbursements $13,500.00; for all of which proper vouchers are on file and have been by us examined and found correct, thus leaving no balance.

And we further certify that the expenditures have been solely for the purposes set forth in the Act of Congress approved March 2, 1887.

(Signed.)

H. B. LORD,
MYNDERSE VAN CLEEF, } Auditors.

(Seal.)
Attest: EMMONS L. WILLIAMS,
Custodian. (Signed.)

REPORT OF THE CHEMIST.

To the Director of the Cornell University Agricultural Experiment Station.

SIR :—

I have the honor to report the following account of the work that has been done in the Chemical Division of this Station during the year 1898–1899.

Forty-two analyses of cattle foods, of which twelve were condimental; ten analyses of soils for nitrogen, phosphoric acid and potash; ten analyses for water only; nine analyses of various substances for fertilizer constituents; thirteen analyses of insecticides for arsenic, copper and in some cases other constituents.

Much time was given for three months in the fall to the determination of sugar in sugar beets grown in the State for experimental purposes. Also much time has been consumed in working out and testing methods of analysis of some of the new insecticides, in order that the published results should be accurate and reliable. Many of these substances are offered as substitutes for Paris green, and contain other constituents than copper combined with the arsenic. Some are colored with dye stuffs to imitate the color of the regular Paris green.

Respectfully submitted,

G. C. CALDWELL,
G. W. CAVANAUGH.

REPORT OF BOTANIST.

To the Director of the Cornell University Agricultural Experiment Station.

SIR :

During the year investigations have been conducted upon the diseases of trees, cultivated plants, and upon edible and poisonous fungi. Along with the studies of the edible and poisonous mushrooms, a large number of photographs have been added to those heretofore made, and descriptive studies and determination of plants has added to the material available for future bulletins. These are designed to be educational helps for the purpose of spreading a popular and yet accurate knowledge of certain species which are useful as food. One bulletin (168) the second in the series of "Studies and Illustrations of Mushrooms, II," dealing with Three Edible Species of Coprinus has been published.

In the investigations on the diseases of trees a large number of photographs have also been made and material collected which shows in many cases characteristic injuries due to certain species of the wood destroying fungi. Some of the results show definitely the mode of attack of the fungus and the progress of the disease in the timber trees.

The investigations carried on by Dr. B. M. Duggar have been chiefly upon three diseases of the sugar beets, and upon the prevention of the leaf curl of the peach. Two bulletins written by Mr. Duggar have been published as follows :

No. 163—"Three Important Diseases of the Sugar Beet."

No. 164—"Peach Leaf-Curl and Notes on the Shot-hole Effect of Peaches and Plums."

In Bulletin No. 163 Mr. Duggar treats of the three diseases which have been of economic importance on the sugar beet in New York State. The root rot of beets (Rhizoctonia betæ) is a new disease on the beet for the eastern states. Mr. Duggar's studies have shown the conditions which are favorable for the

production of the disease, and indicate that remedial measures can be successfully applied. The other two diseases are the Leaf Spot (Cercospora beticola) and Beet Scab (Oospora scabies).

Mr. Duggar's experiments with leaf-curl of the peach (Bulletin No. 164) show quite clearly that this very serious disease which has been prevalent in New York State for the past two years can be largely prevented by timely spraying.

Mr. Duggar has also written two circulars as follows:

No. 4—"How the Plant obtains Its Food from the Soil."
No. 5—"How the Plant Obtains Its Food from the Air."

Ths investigations in progress for the coming year are to be continued along these same lines, especial attention being given to studies of edible and poisonous mushrooms, the wood destroying fungi injurious to forest and shade trees, and to diseases of fruit and farm crops.

Doctor Duggar is now in Europe where he will remain for one year, for the purpose of perfecting himself in certain lines of research in plant physiology. This subject is a very important one in connection with the investigations on plant diseases due to fungi and certain plant diseases are due entirely to physiological causes. During Dr. Duggar's absence Mr. W. A. Murrill is carrying on the investigations which he had in charge.

Respectfully submitted,

GEO. F. ATKINSON.

REPORT OF ENTOMOLOGIST.

To the Director of the Cornell University Agricultural Experiment Station.

SIR :

As the Entomological work of the Station has been performed during the past year almost entirely by the Assistant Entomologist. I have requested him to prepare a report on it, which I herewith transmit.

Very respectfully yours,

J. H. COMSTOCK.

To the Entomologist of the Cornell University Agricultural Experiment Station.

SIR :—

The general plan of the work done by the Entomological Division of the Station during the past year has been the same as in previous years. While fragmentary notes are constantly accumulating on many different kinds of insects, we have aimed to make an exhaustive study of only a few injurious ones. Over 600 different insects are now enrolled on our records, and almost every year some valuable fact is added to our notes regarding each one of these insects. In many cases, like that of the San José scale, the Codling-moth, the Army-worm, and others, our notes would fill a large volume in each case.

Some of the results of our investigations during the past year were embodied in the following bulletins :

No. 157. "The Grape-vine Flea-beetle."
No. 170. "Emergency Report on Tent Caterpillars."

We have just completed our observations upon tent caterpillars which were begun last fall, and expect to submit a more detailed bulletin about these pests during the coming year. The forest species of these caterpillars has wrought almost untold devastation in the forests, orchards, and shade trees of the eastern half of the State. Our emergency report upon them was

distributed freely in every locality where our attention was called to their ravages, with the result that much interest was aroused among the school children, as well as their parents, and in some cases thousands of the caterpillars or their cocoons were collected by the pupils and destroyed. In many places the warfare will be continued by the children against the egg-rings in the fall. This bulletin has, therefore, done much to stimulate Nature-Study in many places, while it has also been one of the most practical and valuable publications for the farmer that the Entomological Division has ever issued.

Some very important investigations which have been under way for one or more years were completed during the past year. For example, our observations on Canker-worms, which still continue their extensive ravages in western New York, are now complete and we hope to get our notes in shape for publication in time to enable fruit-growers to use the information next year.

And again, for four years past we have been making careful and scientific tests of the different washes and other devices which have been recommended and which we could devise to circumvent that constant menace to peach culture—the peach borer. Our experiments are now finished, the literature of the insect has been thoroughly studied, and a bulletin embodying our observations and results will be written at once.

We also have other material awaiting an opportunity to be written up for publication. The fact that we have so much valuable information in a crude state in our notes, has led us to undertake no new lines of investigation during the past six months. Whenever such work is undertaken it involves all of the time we can spare from our routine duties. The examination, determination, and care of the large amount of material which is sent in to the Entomological Division ; the making and arranging of notes, photographs, etc.; the answering of correspondence ; the attendance as lecturer at many Farmer's Institutes and Horticultural Meetings ; and the giving of a course of lectures in the University in the winter—all these duties so encroach upon our time that oftentimes little is left for original investigation or for preparing our results for publication.

The correspondence of the Division increases every year.

Our daily mail now often averages from five to ten letters, and it is not limited to our State or the United States, but includes Europe and such remote regions as Australia and South Africa. This extensive correspondence; our frequent contributions to the agricultural press ; our personal contact with many of New York's leading farmers and fruit-growers in attendance at Farmer's Institutes, Horticultural Meetings and other similar gatherings, are resulting in the work of the Entomological Division being brought in closer touch with, and being more and more appreciated each year by the people.

Respectfully submitted,

M. V. SLINGERLAND.

REPORT OF THE AGRICULTURIST.

To the director of the Cornell University Agricultural Experiment Station.

SIR :—

Since my last report the following bulletins have been published by the Agricultural Division of the Experiment Station :

No. 156—"Third Report on Potatoes."
No. 166—"Report of Sugar Beet Experiments for 1898."
No. 167—"Construction of the Stave Silo."

Work has progressed favorably along the lines heretofore reported upon and some new lines of work have been commenced. While experiments with potatoes and sugar beets have been under way for some years, yet it has been deemed wise to pursue the investigations still further as it is found that each year's work adds something to our knowledge concerning those crops. Interesting and possibly valuable results have already been obtained from experiments in the renovation of pastures. This line of work will be pursued vigorously in the attempt to learn what treatment is best for the restoration of old depleted pasture lands.

During the present year the June droughts so shortened the hay crop in many portion of the state that there was an urgent request for information as to what crops might be most profitably grown to supply additional roughage for stock during the winter. To enable us to give accurate information in the future a test is being made of various forage plants to determine which are best adapted for late planting. A study of legumes has been in progress for two years, the experiments being mostly confined to clovers. This line of work has been continued and various investigations have been commenced with beans. Preparations are now under way for an extensive study of legumes as soil renovators.

In my last report I called attention to the importance of

acquainting the farmers of the state with the results which have been secured in our work. Co-operative experiments throughout the state are now being conducted by Mr. J. L. Stone, Assistant in Agriculture under the "Nixon Fund." Several hundred farmers are conducting under his supervision tillage and fertilizer experiments with potatoes, sugar beets and beans. These co-operative experiments are most valuable in that they enable us to test methods under various conditions, and they also serve as object lessons to the farmers of the state.

Respectfully submitted,

L. A. CLINTON.

REPORT OF THE HORTICULTURIST.

To the Director of the Cornell University Agricultural Experiment Station.

SIR :

The experimental work under my charge for the past year has concerned itself chiefly with studies of various phases of fruit-growing. At the home station, the Japanese plums have received continued attention, and it is expected that a fourth report will be issued the coming fall. Various treatments and studies in the experimental orchards, especially those corcerned with tillage and fertilizing, are our staple subjects of inquiry. A new vineyard is now planted, in which similar studies are making. The testing of varieties of fruits has never been a part of our work, except in a few special lines (as the Japanese plums) to which we have been able to give very systematic study.

In Oswego County the experiments in fertilizing and spraying strawberry fields still goes forward; and results of much importance have been secured. It is desired to have another season's experience before publishing, however. At the present time we control an experimental acre in three places in the county.

The forcing of fruits is a subject of inquiry. We are continuing the study of winter strawberry-growing, upon which we have already published one bulletin; and in the present season we have fruited peaches and apricots under glass. Other kinds of fruit are now ready for forcing. I must call your attention to the fact, however, that we have no houses which are well adapted to this work.

In vegetables, we are studying a variety of problems. For two years we made tests with celery in some of the bottom lands of Orange County upon which onions,—which has been the staple crop,—have failed. The purpose was to determine whether celery can be grown commercially on that soil; and, if so, to instruct the people how it may be done. The result has

shown that the land is well adapted to celery; and the gardeners there are now beginning to plant it for themselves.

Experiments in controling the San José scale have been reported in two bulletins (Nos. 144, 155). Very careful studies in the same direction are now progressing, along with general tests of new insecticides and fungicides.

For two seasons, extensive studies have been made of the problems associated with pollination and self-sterility in orchards; and the results now await publication.

Various problems associated with flowers and ornamental gardening are still receiving attention. The leading subjects just now are studies of the geranium, of which we have many hundred varieties, and plants for screens.

Respectfully submitted,

L. H. BAILEY.

REPORT OF THE ASSISTANT PROFESSOR OF DAIRY HUSBANDRY AND ANIMAL INDUSTRY.

To the Director of the Cornell University Agricultural Experiment Station.

SIR :—

The work of the Dairy Division of the Experiment Station has been considerably expanded and enlarged owing to the increased facilities provided under the State appropriation, Chapter 67, Laws of 1898. During the summer months several dairy schools giving practical instruction in butter and cheese making were held in various parts of the State. In addition to the instruction thus given, we have had many requests from creameries and cheese factories for assistance in special difficulties, and we have been able to render such assistance in almost, if not quite, every case. The call upon our department for men to supervise butter tests of thoroughbred cows has been greater during the past year than ever before.

Investigations in Dairy Bacteriology have been carried on through the year and some valuable results obtained, notably in the study upon "Ropiness in Milk and Cream." Our Bacteriologist, Mr. A. R. Ward, has recently removed his laboratory from the Veterinary College to the Dairy Building where he will continue these investigations.

The subject of "dilution" in raising cream has occupied considerable attention. Manufacturers of so-called "Dilution Separators" have been scattering their wares over the State and scores of inquiries concerning their merits have come to our office. In order to secure new and accurate information with which to answer these inquiries we made careful tests of the "separators" both at our laboratory and also at several farms where we found them in daily use. The results of our tests, which show that the dilution of milk for raising cream results, in most cases, in a great loss of butter-fat, were published in

Bulletin No. 151. Another bulletin treating of Patents on Dilution Separators is now in press.

A large amount of material which had been accumulating for the past ten years has been published in bulletin form, and still more is nearly ready for publication. The bulletins issued by this division during the year are as follows:

No. 151. "Gravity or Dilution Separators."

No. 152. "Studies in Milk Secretion drawn from Officially Authenticated Tests of Holstein-Friesian Cows."

No. 158. "An Inquiry Concerning the Sources of Gas and Taint Producing Bacteria in Cheese Curd."

No. 162. "The Period of Gestation in Cows."

No. 165. "Ropiness in Milk and Cream."

No. 169. "Studies in Milk Secretion drawn from the Records of the University Herd, 1891–98."

Respectfully submitted,

H. H. WING.

APPENDIX I.

BULLETINS PUBLISHED JUNE 30, '98—JULY 1, '99.

No. 150. Tuberculosis in Cattle and its Control.
No. 151. Gravity or Dilution Separators.
No. 152. Studies in Milk Secretion.
No. 153. Impressions of our Fruit-growing Industries.
No. 154. Tables for Computing rations for Farm Animals.
No. 155. San José Scale.
No. 156. Third Report on Potato Culture.
No. 157. The Grape-vine Flea Beetle.
No. 158. Source of Gas and Taint producing Bacteria in Cheese Curd.
No. 159. An Effort to Help the Farmer.
No. 160. Hints on Rural School Grounds.
No. 161. Annual Flowers.
No. 162. The Period of Gestation in Cows.
No. 163. Fungous Diseases of the Sugar Beet.
No. 164. Peach Leaf Curl.
No. 165. Ropiness in Milk and Cream.
No. 166. Sugar Beet Investigations for 1898.
No. 167. The Construction of the Stave Silo.
No. 168. Studies and Illustrations of Mushrooms; II.
No. 169. Studies in Milk Secretion.
No. 170. Tent Caterpillars.

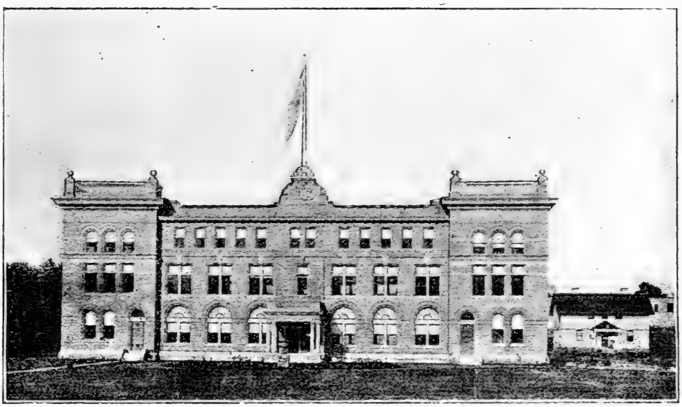
Bulletin 150. July, 1898.

Cornell University Agricultural Experiment Station,

ITHACA, N. Y.

VETERINARY DIVISION.

Tuberculosis in Cattle and its Control.



NEW YORK STATE VETERINARY COLLEGE.

By JAMES LAW.

PUBLISHED BY THE UNIVERSITY,

ITHACA, N. Y.

1898.

ORGANIZATION.

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L. A. CLINTON, Agriculture.
B M. DUGGAR, Botany.
J. W. SPENCER, Extension Work.
J. L. STONE, Sugar Beet Investigation.
MISS M. F. ROGERS, Nature Study.
A. L. KNISELY, Chemistry.
C. E. HUNN, Gardening.
W. W. HALL, Dairy Husbandry.
H. P. GOULD, Horticulture.
W. MILLER, Floriculture.
G. N. LAUMAN, Horticulture.
A. R. WARD, Dairy Bacteriology.
L. ANDERSON, Dairy Husbandry.

OFFICERS OF THE STATION.

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Office of the Director, 20 Morrill Hall.
The regular bulletins of the Station are sent free to all who request them.

TUBERCULOSIS IN CATTLE AND ITS CONTROL.

BY JAMES LAW.

PREVALENCE AND RELATIVE IMPORTANCE.

Our interest in tuberculosis centers in two leading questions: First, its prevalence in man; and second, its diffusion among domestic animals which furnish food for man. If we consider the disease in man only, we must view it first in its sanitary relations, and, as regards the measures available for its restriction, in its moral bearings. If we consider the disease in the domestic animals we enter largely into its economic bearing, but in view of the use of these animals and their products for human food the sanitary and moral questions must also be admitted.

MAN: GENERAL MORTALITY.

In man it is admitted that, in civilized countries, where data can be secured, one death in seven is due to tuberculosis. Allowing 15 deaths per 1,000 on our 70,000,000, this would furnish 150,000 deaths per annum from tuberculosis in the United States. Dr. Osler, of Johns Hopkins University, says this is a very low estimate. A war which should leave 150,000 dead on the battle field every year would rouse the nation to put a speedy end to the destruction. The mortality from tuberculosis exceeds the combined deaths from war, famine, plague, cholera, yellow fever and smallpox. Yet we have those among us who deprecate any intelligent measure for the extinction or restriction of this source of such a constant mortality and loss.

The mortality from tuberculosis in man rises far above this ratio when conditions are favorable to its propagation. In some large cities (Vienna) the ratio of deaths from tuberculosis is more than double what it is for the entire country. In the Marquesas

Islands it rises to 33 per cent of the total mortality, and in some of our Indian reservations to 50 per cent. (Treon, Holden.)

TUBERCULOSIS IN ANIMALS.

Tuberculosis is rare in cold blooded animals, but Sibley has seen it in *reptiles* in a state of confinement.

In *birds* it is common and destructive, but not readily transferred from bird to mammal. The bacillus of the bird is usually a modified form, which prefers a special avian habitation.

Wild mammals in confinement suffer excessively. In menageries apes die almost exclusively from tuberculosis, while kangaroos, deer, elk, gazelle, antelope and lions are common victims. The rats, mice and other vermin about our houses and barns also contract the disease and all must be recognized as possible bearers.

Cattle suffer more than any other domesticated animal, and tuberculous cattle are especially to be dreaded seeing that they furnish so much food for consumption by man. The Danish herds which were said to be sound until after the importation of Schleswig and Shorthorn cattle in 1840 and 1850 are now generally infected, 17 per cent of the cattle slaughtered showing tuberculosis, while over 60 per cent of the dairy herds showed the disease under the tuberculin test. Statistics from German abattoirs give, for cows 6.9 per cent tuberculosis, for oxen 3.6 per cent, for bulls 2.6 per cent, and for yearlings and calves 1 per cent. In Berlin abattoirs 15 per cent proved tuberculous. By the tuberculin test of New York State herds (2,417 head) in 1894 16.75 per cent proved tuberculous. This is undoubtedly too high an estimate for the entire cattle of the State, as the herds were examined because the owners suspected them and requested examination by the tuberculosis commission. Yet it cannot be said that this represents the extreme of infection as I have found one herd of 60 and another of 200 in country districts of this state tuberculous without exeeption. These represented cases in which no precaution had been taken to prevent contagion.

Swine are also very subject to tuberculosis, especially through the consumption of the uncooked offal of slaughter houses and of the milk of tuberculous cattle.

Rats and mice readily contract the disease from feeding in the mangers of tuberculous cattle and swine, and in their turn carry the disease from manger to manger and from barn to barn.

Rabbits, Guinea pigs and goats when left at large do not readily contract the disease but are very susceptible to the infection when it is conveyed to them experimentally.

Horses, asses, dogs, cats and sheep do not readily contract the disease under ordinary circumstances, but this cannot be attributed mainly to insusceptibility since one and all take it easily when inoculated. The habitual immunity is therefore largely due to the absence of opportunity for infection, and in some degree also to the outdoor life and the well developed state of the muscular system and blood. For the house dog and cat infection has often come from eating scraps from the plate of tuberculous people and in some instances from licking up the expectoration. At Alfort only 40 dogs were found tuberculous in 9,000 *post mortem* examinations.

TUBERCULOSIS CONTAGIOUS.

That this disease is contagious was recognized by many of the medical lights of the 16th to the 18th centuries. Morgagni, Læennec, Cullen, Wickman, Valsalvi and Sarconi, and for animals, Ruhling, Krunitz, Fromage, Huzard and others leave evidence corroborating this belief. The civil and ecclesiastical laws joined in forbidding the use of the meat from tuberculous animals, and in prescribing the destruction or disinfection of articles that might have become infected from tuberculous persons.

This was placed on a solid basis by the many successful experimental inoculations of the disease by Villemin in 1865 and by his numerous followers, who conveyed the disease by feeding tuberculous matter, and by causing the animals to inhale tuberculous liquid in the form of spray. Finally, Robert Koch, of Berlin, completed the demonstration, placing the keystone in the great arch of evidence, by the discovery of the tubercle bacillus, which he invariably found in the diseased tissues and in no others, and which he cultivated in pure culture in glycerine

bouillon, and inoculated successfully upon a large number of animals.

Since that time (1882) his position has been corroborated by all competent observers, and there is no truth in medicine more thoroughly established to-day than the essential connection be-

Fig 1.

1.—*A drawing from a preparation of tubercle bacilli magnified about 1000 diameters.*

tween tuberculosis and the tubercle bacillus. This bacillus has been so often conveyed with destructive effect from man to the smaller mammals, and even to cattle, that the essential identity of human and bovine tuberculosis must be accepted. This statement requires the qualification that the bacillus, like other pathogenic germs, adapts itself to the conditions of the medium on which it grows, and therefore, in the first place to the particular genus of animals in which it has been living for some time, and is therefore often less ready to grow in one of another kind

than in one of the same genus. The most extreme example of this is found in the bacillus of the bird which can only with difficulty be made to grow in the system of the mammal.

But even in the mammal the virulence of the bacillus for other mammals of a different genus or species may be very varied.

Theobald Smith obtained, from a pet bear that had been owned by a tuberculous master, bacilli which seemed to have no ill effect when inoculated on cattle, and had a somewhat reduced virulence for Guinea pigs. Kruse found bacilli from human sputum, and others from the lungs of cattle which produced only local tubercle in Guinea pigs.

Clinical observations show that the same is true as between different individuals of the same genus and species, and hence we find instances of tuberculosis in given herds, which continue for a number of years with few cases showing generalized and fatal results; and other instances of herds in which the disease makes rapid progress, soon affecting all or nearly all of the animals, and proving fatal to a number in rapid succcession.

This modification of the germ by its surroundings is again well shown in the common experience that it is usually difficult to start (on artificial media in flasks) the growth of tubercle bacilli taken direct from the animal, but when once started and accustomed to grow on such new materials, it may be started again in fresh culture with great certainty.

In stating, therefore, that the one and only cause of tuberculosis is the tubercle bacillus, it is not to be understood that it is affirmed that that bacillus is at all times, under all circumstances and to all animals, equally virulent and destructive. If the conditions are favorable it will prove very deadly, while, if unfavorable, it may linger for a time without producing much obvious effect on the general health. Its presence, however, in any herd is a constant menace to all members of the herd, to the attendants, to the consumers of the meat and dairy products of the herd, and to other herds into which members of this herd may be sent. It is also worthy of note, that the power of adaptation of the germ to its surroundings, introduces this further element of danger that, as it becomes adapted to its life in a given animal or in the different members of a closely bred

herd, in the natural course of events it must become better and better adapted to survival in that particular animal and breed, and hence increasingly dangerous to all of its members. This is one reason why tuberculosis is so liable to become intensified in special herds of thoroughbred stock, and why common cattle with a varied ancestry will sometimes seem to offer a longer resistance to the affection. It may also explain the fact that with ample exposure the disease does not always pass from men to cattle and from cattle to man.

Yet it would be folly to argue from such data that the disease, when present in an occult form in a herd, may be safely ignored, and that the products of such herd may be safely consumed by man. The very adaptability of the tubercle bacillus sufficiently contradicts this conclusion. The mere continuous presence of the bacillus in a given system, human or brute, is the means of securing a better and still better adaptation to that form of life, and a greater and still greater measure of potency, so that when the health of the host or exposed animal is in any way reduced it may at once become deadly and far reaching in its evil effects.

CHANNELS OF INFECTION.

Among the channels of infection the following may be noted:

1. *Inhalation by the breath.* This is perhaps the most common method of infection and is usually followed by tuberculosis of the throat, lungs, and lymphatic glands of the chest. Expectorations and other infecting discharges are dried up and raised in dust so that they can be easily inhaled. Cases of this kind have been observed in buildings in which a victim of advanced tuberculosis was employed. The other employes fell victims, one after another, to the infection. They are quite common in infected barns, in which the virulent dust carried in the air is inhaled by a number of animals. Experimentally it has been shown by mixing virulent matters in liquids, atomizing them and causing animals to inhale the spray. In the hands of Villemin, Koch, Thaon and Tappeiner this almost infallibly produced tuberculosis of the lungs. In man too, many infections and reinfections have been traced to the dust from the soiled handkerchiefs. On the other hand it must be distinctly understood that

the breath of the tuberculous is not in itself infecting, and if care is taken to prevent the diffusion of the infected solids and liquids and their distribution in dust, the presence of a tuberculous individual is not a threat to others adjacent.

2. *Infection through food and drink.* A whole host of experimenters have conveyed the disease by mixing infecting pus or an emulsion of the tubercle with ordinary food. The same has been often accomplished with milk from the infected animal even to cases in which the mammary glands seemed to be perfectly sound. The danger of course is enhanced in ratio with the number of bacilli present, so that one diseased cow in a large herd leads to little infection if the milk of the whole herd is mixed. On the other hand such admixture of the virulent milk with the wholesome contaminates the whole to some extent, and inoculation with such mixed milk will often convey the disease when the animals drinking it do not seem to be injured by it.

The infection usually takes place through the tonsils, pharynx or bowels. In ruminating animals it may attack the first three stomachs the contents of which are neutral or nearly so, but it rarely attacks the true digesting stomach the secretion of which is strongly acid. The bacillus is liable to perish or to be so distributed by the acid in passing through the stomach that it is largely shorn of its danger. Among the conditions that favor its safe passage through the stomach may be named indigestion and a too rapid progress of the undigested food through the stomach, a condition which is especially common in young animals: overloading of the stomach: the ingestion of an excess of cold water just after a meal, thereby rousing excessive vermicular movement of the stomach and premature expulsion of its undigested contents: and the enclosure of the infected matter in a mass of fat which the gastric secretions are impotent to digest or emulsionize.

3. *Inoculation in wounds.* This is a common channel of infection in man. Accidental inoculations—in making post mortem examinations have been often noticed since the case of Lænnec ; or in making artificial cultures in the laboratory ; or in washing the clothes of tuberculous persons ; or in dressing the tuberculous sores ; or in making operations, notably that of

circumcision; or in inserting earrings formerly used by tuberculous persons; or in inhaling the infecting dust through a nose excoriated by a catarrh; or in handling infected carcasses in the butcher's shops; or finally through mouth or throat abrasions caused by hard indigestible materials.

4. *Through the mammary glands.* This gland is especially subject to wounds by the horns and to sores and abrasions in connection with milking which form entrance-channels for the bacilli present in the dust of the barn. The opening of the teat is also a door of entry through which the germ may invade the milk ducts and glandular tissue. It is not to be forgotten, however, that the milk gland is especially liable to become infected through the blood which is sent in such enormous quantities through its tissues, and is liable to implant any bacilli which may have entered the blood stream. The gland is, therefore, especially liable to infection from without and within and once infected is a source of the greatest danger to the milk consumer.

5. *Through sexual congress.* In cows the generative organs are often the seat of tuberculosis inducing nymphomania or sterility, and the disease has been repeatedly produced experimentally by smearing the infecting matter on the penis or introducing it into the vagina. The bacillus has even been found in the semen of an infected male so that transmission by this channel to the female can be easily understood. All this has a very direct bearing upon the question of the propriety of using the same sire on the tuberculous and sound, and of the admission of females from tuberculous herds to be served by the sires in sound ones.

6. *Through heredity.* Hereditary transmission of tuberculosis has long been recognized, and until recently accorded a rôle much more important than its infrequency would warrant. Various conditions militate against its occurrence; the fœtus is essentially a carnivorous animal, living on the secretions of the dam and not on the direct products of the vegetable kingdom. It has, therefore, that measure of resistance which inheres in the flesh feeding as compared with the vegetable feeding animal. It may be infected through the semen of the sire, but the rule appears to be that the ovum thus early affected rarely

attains to its full intrauterine development. It may be affected from the tuberculous generative organs of the dam, but here again abortion is liable to cut short the existence of the embryo. In spite of all drawbacks a certain small proportion of the offspring are affected with tuberculosis and come to the full period of gestation. In case of infection from the dam the disease is especially liable to attack the liver in which so much of the placental blood at once circulates. Cases of the kind are recorded by Malvox, Brouwier, Bang, Lungwitz, Bärlund and Rieck, and in the tuberculous herd of a large public institution in New York several instances were noted.

The infrequency of such an occurrence may, however, be inferred from the fact that in 800,000 calves slaughtered only 7 were found tuberculous.

INDESTRUCTIBILITY OF THE BACILLUS TUBERCULOSIS.

The bacillus may be said to be capable of surviving drying, the action of water, and putrefaction. It is destroyed by heat (162° to 212° F), sunlight, or in one month by heavy salting.

CONDITIONS WHICH FAVOR TUBERCULOSIS.

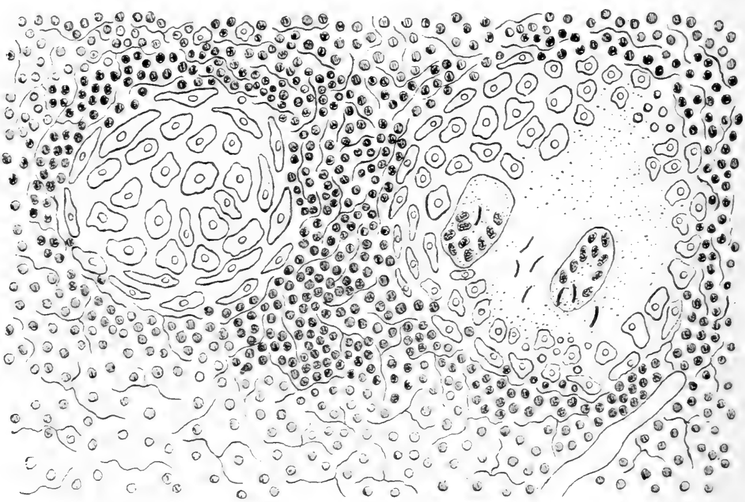
A personal predisposition to tuberculosis is a prime requisite, and this is rendered hereditary by close and inbreeding and breeding in line. Hence the great danger of tuberculosis among improved breeds. Again whatever undermines the health or stamina, such as breeding before maturity, breeding and heavy milking, breeding the old and debilitated, an insufficient ration, an ill-balanced ration which stimulates unduly the secretion of milk, ill health, local inflammations in the air passages, lack of ventilation, constant stabling in dark, damp, undrained stables and wet soils, greatly favor the reception of the bacillus. The impure air, lack of sunshine and accumulation of the germs in large cities make a destructive combination. In France, cities of under 10,000 lose 1.8 per cent yearly from pulmonary tuberculosis, while Paris with its 2,000,000 loses 4.9 per cent. In Vienna hospitals 85 per cent of the bodies show tubercular lesions. In

Bavarian Monasteries 50 per cent of the young postulants die in a few years tuberculous. In New York City charity hospital 30 per cent of all deaths show tubercle lesions. Where country cows are tuberculous to from 1 to 5 per cent, city cows are so from 6 to 20 per cent and upward. On the contrary our prairie and plains fat cattle show but 0.02 per cent tuberculous. In the Southern States with an unbroken outdoor life country cattle are nearly all sound, whereas in large cities like New Orleans they are largely tuberculous.

APPEARANCE AND FORMATION OF TUBERCLE.

The term tubercle is drawn from the rounded nodular form of the diseased process. The bacillus lodged in the tissue multiplies

Fig. 2.



2.—*A drawing of a section of a very young tubercle in spleen.* (*Thoma*).

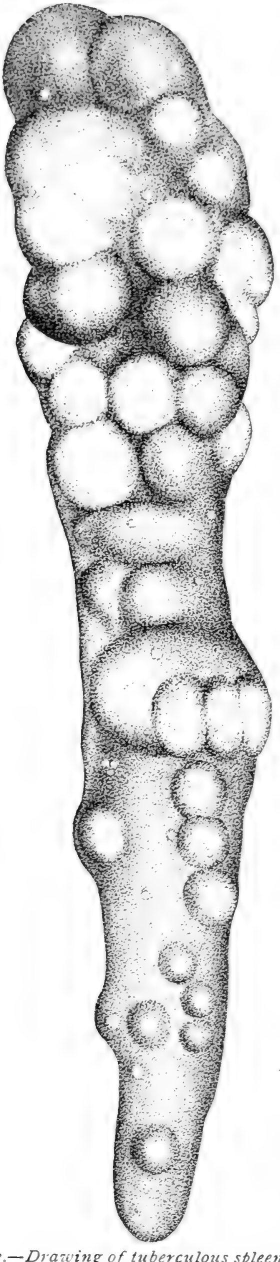
and causes congestion and extraordinary growth of cells. The affected points may be at first no larger than millet seed, but these may increase and run together so as to form conglomerate masses of one, six or nine inches in diameter. As the cell growth increases, the central ones degenerate, die, and form a yellowish

white, soft, cheesy mass (caseation) and these numerous cheesy centres become very characteristic of the disease. Sometimes the tubercle develops into a hard fibrous mass the centre of which may still caseate. In other cases it becomes calcareous or gritty a condition which is usually associated with caseation. Sometimes the caseated mass softens into a whitish cream-like fluid.

COMMON SEATS AND SYMPTOMS OF TUBERCLE IN CATTLE.

Tuberculosis of the lungs may be chronic or acute. The chronic cases may last indefinitely with no other symptom than an occasional cough on leaving the hot stable for cool air, when suddenly raised in the stall, when made to run, or when drinking cold water or eating dusty food. The cough is usually small, dry, wheezing and repeated several times in succession. The general health may seem to be good, the subject may be fat or a heavy milker. To the trained ear, wheezing, crackling, or other unnatural sounds may be heard in the lungs or they may fail of detection. There may be a discharge from the nose, which when stained and placed under the microscope may show bacilli, but by cleansing the nose with the tongue the animal may make this test practically impossible.

Acute tuberculosis of the lungs on the other hand may prove fatal in a month. It is attended with rapid loss of condition, staring coat, elevated temperature, hurried breathing, frequent weak, husky or rattling cough, heavy, mawkish breath, and nasal discharge containing gritty particles or opaque yellowish masses. Pinching of the back, breastbone or spaces between the ribs, or striking the ribs with the knuckles may cause wincing, groaning or cough, and auscultation over the ribs may detect sounds of friction, wheezing, creaking, crepitation, rattling, or blowing, etc. Percussion over the chest detects areas of lack of resonance corresponding to the seats of tubercles or pulmonary infiltration. A significant feature is that these areas of flatness are distributed over the lungs, and not confined to one spot as is common in pneumonia. Appetite and rumination fail, bloating occurs after meals, the bowels may become irregular, and



3.—*Drawing of tuberculous spleen in pig, showing tubercles 2-3 the natural size.*

indications of tuberculosis in the throat, or superficial lymph glands may appear.

Tuberculosis of the stomach and bowels is common in young animals living on milk but is not infrequent in the mature animal as well. It may come from infected milk, or from the swallowing of the diseased products coming from tuberculous throat or lungs. In calves there may be noted indigestion, fœtid diarrhœa, bloating, and finally cough and expectoration or swelling of the superficial lymph glands. In older cattle there may be irregular appetite and rumination, bloating after meals, costiveness alternating with diarrhœa, colics, and marked emaciation. The oiled hand introduced into the rectum may detect the enlarged mesenteric glands, which must be carefully distinguished from hardened fœces in the bowels, from the ovaries, from masses of fat, and from the cotyledons of the womb.

Tuberculosis of the womb and ovaries may depend on infection by the bull, or may be a complication of intestinal and peritoneal tuberculosis. It is usually marked by sterility, abortion, by frequency and intensity of œstrum, and by marked emaciation. Sometimes there is a white vaginal discharge.

Tuberculosis of the liver, spleen and pancreas is also a common accompaniment of infection of the bowel or abdominal cavity. The liver and spleen are especially liable to suffer from being on the line of circulation of the portal vein which brings blood from all the

other abdominal digestive organs. The lymph glands on the posterior aspect of the liver are especially liable to suffer. With liver-tuberculosis there may be jaundice accompanied by other symptoms of digestive trouble, but as in the affection of the spleen and pancreas there is oftentimes only an indefinite ill health.

Tuberculosis of the kidneys may be attended by extra tenderness of the loins to pinching and by frequent passage of urine, which may be discolored by blood or pus. The urine is likely to contain microscopic cylindroid casts and when stained these may show tubercle bacilli.

Tuberculosis of the udder is usually manifested by a circumscribed or general swelling of one or more quarters, without at first special tenderness, and this gradually extends to the whole gland. The milk may be watery, grumous, or even bloody and the lymph glands in front of the udder and behind are enlarged and hardened. The tuberculous nature of the lesions can only be certainly determined by the discovery of the tubercle bacillus in the milk, by the successful inoculation of the milk on a small animal, or by the tuberculin test.

Tuberculosis of the throat and pharyngeal lymph glands is one of the most common forms of tuberculosis in cattle. It causes a wheezing breathing, glairy discharge from the nose or mouth, difficulty in swallowing and a loose gurgling cough. The diseased glands may be felt as soft swellings around the throat, or as shrunken hard nodular bodies, or as masses fluctuating by reason of their liquid contents. When the disease extends to the interior of the larynx it causes a persistent, paroxysmal, husky cough.

The lymph glands inside the lower jaw or those near the root of the ear may swell up, soften and discharge a cheesy or thick creamy fluid containing the bacillus.

The lymph glands inside the chest—bronchial mediastinal, etc.,—are especially liable to suffer, as they receive the infected lymph which comes from the diseased lungs. These often suffer when no lung disease can be found, the bacilli having passed through the lung without forming any primary lesion in that organ, or those that have been formed having healed. These are often attended by no distinctive symptoms, and require the tuberculin test.

Lymph glands in front of the middle of the shoulder blade may be suspected if of unequal size and form on the two sides, if hard and nodular, or if soft and fluctuating. They rarely caseate and burst.

Other lymph glands that may be similarly affected, and that are superficial enough to be felt, are the *glands at the entrance of the chest* in front of the two first ribs, the *glands on the flank* above and in front of the stifle, and, in the young, the *glands situated high up in the groin.*

Tuberculosis of the bones and joints is seen in young growing animals, affecting especially the large joints of the limbs, the elbow and knee, the stifle and hock, but also at times the bones and joints of the digits. The ends of the bones become enlarged and tender and the joints overdistended, tense and elastic. The lameness may be extreme.

PROPORTION OF OCCULT CASES.

In herds which have the disease in the most intense form, by reason of long standing, indoor life, and repeated reinfection nearly all may be detected by the objective symtoms, but in such herds nearly every animal is diseased. In ordinary herds, where the disease is less intense, at least two-thirds of the diseased animals would escape under such an examination. In one herd of 70 head in which the tuberculin test condemned 24 head (being 50 per cent of the mature animals) I left the examination after slaughter to the veterinarian of the A. J. C. C. who was at the time skeptical as to the value of the tuberculin test. He wrote me afterward of his surprise at finding every one of the 24 condemned animals tuberculous, when not one of them had shown symptoms by which he could recognize the disease in life. This is no exceptional case, and may be advanced rather as a typical example of the ordinary infected country herd.

It is manifest that if we aim at speedily and certainly clearing a herd of tuberculosis we must have some better method of diagnosing the disease than the best physical examination. Attempts have been made to discover the bacillus in the expectoration, milk or nodular lymph glands, but this requires prolonged care-

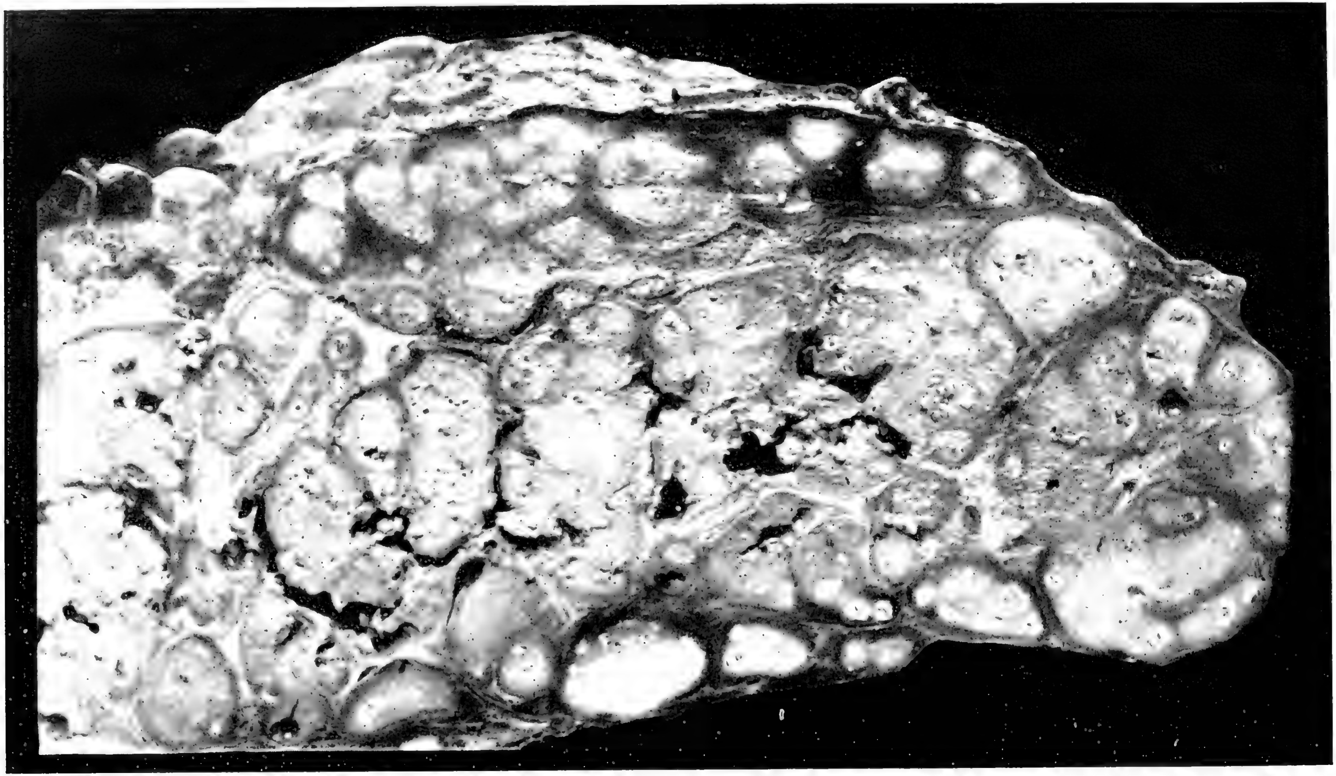


PLATE I.—*Photograph of a section from anterior lobe of a tuberculous lung of a cow, showing rounded tubercular infiltration and calcified centres.*

PLATE II.—*Photograph of a portion of tubercular omentum of a cow, showing the tubercles, natural size.*

ful manipulation in almost every case, and, in case of no bacillus being found, is no guarantee of the absence of the disease.

Inoculations with the suspected discharges, secretions or tissues, demand a delay of one or two months before one can pronounce upon the result, and that result if negative, gives no assurance that the animal is free from tuberculosis but only that the material inoculated did not contain the germ.

THE TUBERCULIN TEST.

Much has been said and written against the tuberculin test by those who have never used it, and who are therefore utterly incompetent either to endorse or condemn it, but for those who aim at the prompt and thorough eradication of the infection from a herd, and at the securing at once of a guarantee of progeny, beef and dairy products, no resort can, as regards its efficacy, be at all compared with the tuberculin test.

Tuberculin is a sterile solution of the products of the artificial culture of the tubercle bacillus. In its preparation it has been treated to a boiling temperature which is as fatal to a tubercle bacillus in liquid medium as it is to a hen's egg. But this is not all, even the dead bacilli have been separated from the liquid by passing it through a porcelain filter. The remaining liquid (tuberculin) is absolutely sterile and can plant and propagate neither the tubercle bacillus nor any other living thing. It can poison if given in excessive doses, as alcohol can poison, but it can no more produce the germ of tubercle where that does not exist than can distilled alcohol plant the yeast germ and start a new vinous fermentation. The insane fear of tuberculin is the fruit of an ignorance of its true nature and of a blind prejudice which withholds its victim from informing himself on the subject.

As we produce tuberculin in the bacteriological laboratory of the N. Y. S. Veterinary College, and distribute it free, for use by approved parties in this state, we can speak with confidence of the absolute harmlessness of the agent when intelligently employed. We aim at securing no profit in making this agent, but charge only for packing and shipping. We have therefore no interest in its manufacture, for on the contrary the greater

demand from residents of this state for tuberculin the more unremunerated labor is heaped upon us.

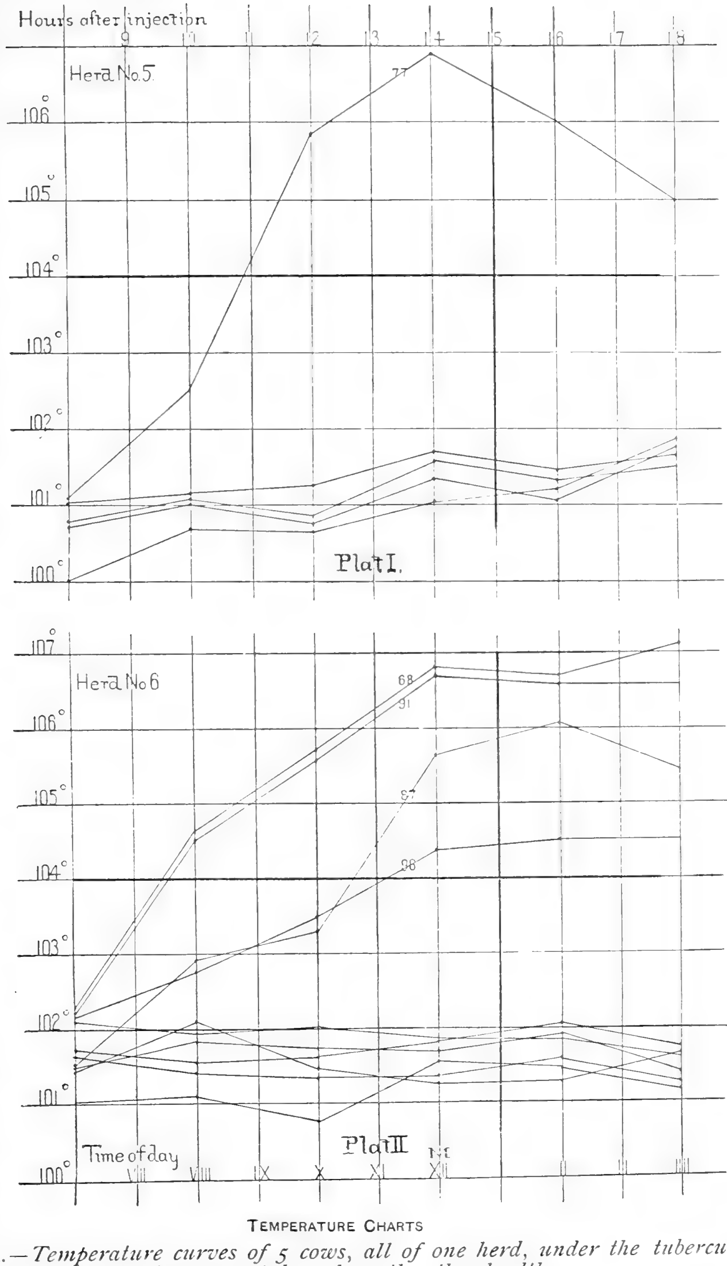
The value of the agent consists in this, that the hypodermic injection of an appropriate dose in a tuberculous animal, however lightly affected, produces in the course of the succeeding twenty-four hours a rise of body temperature and other indications of fever. The gradual rise and fall of the temperature in the absence of any other diseased or physiological condition which would bring this about is the most reliable of all symptoms of the presence of the disease. Upon the sound animal system such a dose of tuberculin produces no appreciable effect.

It is important, however, that I should not be misunderstood in this matter. The man who will use tuberculin without due caution and without due consideration as to the condition and environment of the animal, and who blindly condemns on any rise of temperature will almost certainly condemn non-tuberculous animals and bring the tuberculin test into discredit. The intelligent use of the test, demands an intimate knowledge of the kind of animals tested, both in the healthy and diseased condition, and a careful scrutiny before and during the test.

1st. *The subject must be in good general health.* If there is present in the system any concurrent disease it may undergo an aggravation within twenty-four hours and give a rise of temperature that will be mistakenly set down for tuberculosis. At the very start, therefore, it is important that the general health of the subject should be first assured by a critical professional examination. If some other disease is present the tuberculin test had best, as a rule, be delayed until that has subsided, while if tuberculosis is found the test will be superfluous.

2d. *The subject must not be within three weeks of parturition, nor about to abort.* In many cases, though not in all, as preparations are made for calving, the system becomes unduly susceptible to the presence of tuberculin and that agent will cause a rise of temperature, though no tuberculosis is present. Unless this source of error is carefully guarded against the most valuable cows in the herd may be condemned unjustly.

3d. *The cow must not be within three days of the period at which "heat" would naturally occur.* Under the excitement of œstrum



TEMPERATURE CHARTS

4.—*Temperature curves of 5 cows, all of one herd, under the tuberculin test. No. 77 was tuberculous, the other healthy.*

5.—*Temperature curves of 10 cows, all of one herd, under the tuberculin test. Nos. 68, 87, 91 and 98 were tuberculous, the others healthy. (Curtice, Report of the Bureau of Animal Industry 1893-6.)*

the body temperature usually rises two or three degrees, and if tuberculin has been used this rise may be attributed to tuberculosis and a sound animal may be condemned. Nor is it always enough that the animal is supposed to be pregnant. Abortions sometimes takes place unexpectedly and unknown to the owner. If, therefore, a cow under the test and which is not well advanced in pregnancy should show a rise of temperature it should be at once ascertained whether the animal is not in "heat." If symptoms of "heat" are found she should be set aside along with any calving cows to be tested again when such a source of error is no longer present.

4th. *The tested animal must not be exposed to a hot sun in a closed area.* In excess this will cause heat apoplexy, and the fever heat which ushers this in may easily be mistaken for the indications of tuberculosis.

5th. *Cattle taken from pastures must not be enclosed in a hot, stuffy stable.* While they must be tied up to allow of the temperatures being taken at short intervals, coolness and ventilation should be secured in summer by a sufficient air space and the requisite ventilating openings.

6th. *Exposure to cold draughts between open doors and windows, or to wet or chilly blasts out of doors should be carefully guarded against.* A chill proceeding from any source and alike in the presence or absence of tuberculin causes a rise of the internal body temperature.

7th. *Heavy cows unaccustomed to stand on hard boards may have a rise in temperature in connection with resulting tenderness of the feet.* One must avoid hard floors on the day of the test or make examination of the feet and allow for attendant fever.

8th. *Omission of the previous milking or a change of milker and consequent retention of part of the milk* will raise the temperature of a nervous cow, and in careless hands secure an erroneous condemnation.

9th. *Privation of water at the regular time will often cause rise of temperature* especially when on the dry feeding of winter. I have seen a general rise of two degrees and upward from the delay of watering for a single hour, while after watering the temperature went down to the normal and remained so. Water

always tends to a temporary lowering of temperature but in the presence of tuberculosis it soon rises again.

10th. *Change of food is liable to produce a slight indigestion and rise of temperature.* This should be avoided as far as possible, and when a herd is taken up from pasture for the test it should have grass, ensilage or other succulent food.

These are examples of the sources of fallacy which attend on the reckless and unintelligent use of tuberculin. They only show that skill and training are necessary to its successful use, and that in the absence of these the apparent results are not to be too unhesitatingly accepted. In all cases, in the absence of the requisite education and experience it is desirable that the animals which have shown a rise of temperature should be separated from the herd and tested anew after the lapse of three or four weeks. In this way such errors may be almost entirely excluded.

11th. *An animal with advanced tuberculosis sometimes fails to react.* The subject is, however, usually emaciated and bloodless, breathes hard and has rapid pulse on exertion and shows unequivocal symptoms of tuberculosis to the skilled examiner. Such cases can, therefore, rarely escape a physical examination. They are noticed mainly to guard against the mistake of making the rise of temperature or its absence the sole test of tuberculosis.

12th. It is objected to tuberculin that it detects even the slightest and most latent cases of tuberculosis, some of which would recover and many would remain useful for years. This objection would be valid if our object were to obtain the greatest possible money return from the individual tuberculous cow at the expense of any risk to the sound herd. But tuberculin is, and should be used for the purpose of a complete eradication of the tubercle bacillus from the herd and the preservation of a sound stock which with its products will be above suspicion. If this is not aimed at; if the latent cases are to be retained in the herd and the advanced cases only removed then truly tuberculin should have no place in your system. Physical examination should be all sufficient for your purpose. But you could not place the herd at once above suspicion, you could not sell its members with a guarantee of soundness, and you could not assure the consumers that the uncooked dairy products were safe.

The animal with local tubercle may not at the present time be diffusing the poison, but where such animals are preserved one will at intervals have the local tubercle extended so as to cause generalized tuberculosis; and as this extension necessarily takes place by the conveyance of the bacillus through the blood, and as such bacilli must be circulating in the blood before they can invade new tissues and form new tubercles, it follows that there is always a period between the entrance of such bacilli into the blood and the development of new tubercles in which the blood and all blood-containing organs are infecting, though no symptom nor lesion of new tubercles can be detected. At this stage the animal may convey tuberculosis through its flesh, or through its dairy products, while even a post mortem examination would pronounce it free from generalized tuberculosis. It is also liable to distribute the germ to other members of the herd before any suspicion of immediate danger is entertained.

Deduction. It may be concluded from such considerations as the above that the tuberculin test is indispensible where one aims at a guarantee of the soundness of the progeny and dairy products of a herd, but that its use demands one of two conditions.

A. That the animals showing tuberculosis under the test shall be destroyed and the buildings where they have been shall be disinfected; or,

B. That such infected animals, as have the disease in a latent form, shall be formed into a separate herd and kept well apart from other stock, for breeding purposes only; or if their milk is used that it shall be first subjected to sterilization.

The stockowner who values the sound portion of his herd cannot afford to allow even the latent cases of tuberculosis to mingle with it.

TUBERCULIN IN MODERATE DOSE HARMLESS TO SOUND CATTLE.

The concurrent testimony of all veterinarians drawn from hundreds of thousands of tests is that the ordinary test dose is harmless to a nontuberculous animal. In 1894 I put this to a crucial test on five cows (Holstein, Jersey and grade) injecting the tuberculin on six successive occasions and found that it pro-

duced no appreciable change in the general health as evidenced by temperature, breathing, pulse, yield of milk or quality of milk. I feel accordingly that I can speak with the greatest confidence as to the entire harmlessness of the tuberculin test on a sound animal.

That it rouses into a temporary activity the tuberculosis already existing in the unsound animal is true. Were it not so it would be useless as a diagnostic agent. But if the state stands ready to destroy and pay for the diseased, there can be no possible objection to the temporary aggravation which leads to the purification of the herd.

MEASURES FOR THE ERADICATION OF TUBERCULOSIS.

For the complete eradication of tuberculosis from a herd or country the first and main consideration is the absolute separation of the sick animal and all its products from the healthy. This is fundamental in dealing with all infectious diseases, and if it could be applied would reduce all contagious disorders to the condition of simple sporadic ones. Plagues would cease to be plagues, and the infecting disease would cease like any other affection with the first individual case. The plagues of men follow the great movements of men—pilgrimages, armies, trade. The animal plagues prevail continuously in unfenced territories (Asia, Central Europe, Australia, Tasmania, New Zealand, South Africa), and follow the tract of armies and the channels of commerce. Stop the great accummulations and intermingling of animals and we arrest the general diffusion of a plague and reduce it to the comparatively insignificant importance of some common disease.

Exceptional cases like anthrax and blackquarter in which the germ is maintained for years in the soil, are only apparent exceptions to this fundamental principle, as whenever the germ can thus be carried in soil or water the separation of sick and their products from the healthy is incomplete.

In applying this principle to tuberculosis we meet with the drawback that a great variety of animals of different genera are

susceptible (including the human being) and that it is difficult to keep all these and their products apart, and that further it is not in our power to cut short the disease abruptly in the human race as it is in the lower animals. There is however the counter-balancing advantage that its propagation is slow and takes place less readily through the air than in the case of most infectious diseases.

BREEDING HEALTHY STOCK FROM PARENTS WITH LATENT TUBERCULOSIS.

Where the state is not pledged to exterminate the disease by prompt and radical measures it is quite possible to raise healthy stock from sires and dams that have tuberculosis in a slight and latent form. It will be recalled that calves are usually born free from tuberculosis. In the slaughterhouses of Europe there may be but one tuberculous calf in 100,000 killed. If therefore the calves can be preserved from infection of a parental source they may be raised absolutely sound with very few exceptions. For valuable pedigreed animals especially it is quite possible for the owner to keep those with latent tuberculosis in secluded herds, to remove the calf from its dam as soon as born, and to raise it on the sterilized milk of the dam or on the milk of another and healthy cow.

In such a case it is always desirable to employ the tuberculin test upon the entire herd, to destroy at once those animals that have advanced or generalized tuberculosis, and to separate in a new or disinfected barn under special attendants the cows that have been attested sound. There will remain the slight and latent cases which have reacted under the tuberculin, but which are well nourished, having healthy skins, eyes and appetite, and no cough, wheezing nor shortness of breath. These must be kept well apart in separate barn and pasture where neither they nor their products can come in contact with healthy stock, where they can have good air and nourishing food. Their calves must be kept in a separate building or park, and fed on the milk of sound cows, or on that of their dams after it has been raised to the boiling point for 15 minutes. After sterilization the milk must be put in scalded vessels reserved for the use of the calves,

and fed by the special attendants. Any loss of condition, unthriftiness, cough or scouring on the part of a calf, should be the warrant for separating it from the others and subjecting it to the tuberculin test, and for its destruction in case it shows the tuberculin reaction.

The cows should also be carefully watched and in case any one develops cough, wheezing, breathlessness on exertion, or other sign of actively advancing tuberculosis it should be at once destroyed as endangering the others by possible reinfection. The whole isolated tuberculous herd should be submitted to the tuberculin test, every three or six months, and individuals which fail to react on two successive tests, and which show all other indications of good health may be held to have recovered and may be restored to the healthy herd.

A *second* method is that pursued successfully in the North West Territories. Cows and heifers that have reacted under tuberculin, but which otherwise appear to be in good health, are made into a herd by themselves and placed on a special range apart from all other cattle. They live in the open air with slight shelter in winter and their calves are allowed to suck their dams running with them until winter. The wide range, the open air life, and the early destruction, by sunshine and oxygen, of the discharged microbes, tend in the main to ward off infection except such as comes in the milk, and as a matter of fact the majority of the calves grow up in apparent good health and are fattened and shipped to England.

The climate of our Southern States affords a better opportunity for this practice than does the semi-arctic northwest. There the ranch cattle living in the open air all the year round show little or no tuberculosis, and with this outdoor life the genial climate will greatly favor the survival if not the recovery of the slight and latent cases. It should be added that in the stabled cows of the southern cities tuberculosis is very prevalent.

EXTINCTION OF TUBERCULOSIS WITHOUT THE TUBERCULIN TEST.

As successful examples of this I may quote from my own personal experience.

1st. A herd of about 200 head belonging to the Willard Asylum had become badly affected with tuberculosis and on physical examination, without the use of tuberculin, I condemned about 50 per cent. These were accordingly destroyed and new barns and yards were constructed at some distance from the others and filled with cows selected from the most healthy herds available. These were bred to healthy bulls and a new herd gradually built up. Meanwhile the remaining 50 per cent of the original herd were gradually slaughtered, and like the original half of the herd were found to be tuberculous without a single exception. The original barn was thoroughly cleaned, repeatedly disinfected with chloride of zinc and with its cleansed and disinfected yards was left unoccupied for an entire year. The fields on which the original herd had pastured were used for other purposes than pasture for two full years. The new herd was carefully watched and any cow which contracted a cough or showed especially poor health was at once separated from the herd and disposed of. This treatment of the new herd was kept up for over twelve years, and in the middle of December, 1897, I subjected the mature animals of the herd to the tuberculin test, and found not a single case of tuberculosis. I have never before subjected an untested herd of this size to the action of tuberculin without finding a considerable percentage of cases of tuberculosis. The splendid showing is highly instructive as to the high value of intelligent management even without the aid of tuberculin. Here a large herd was maintained under the same conditions of food, milking and housing (even in the same barns) as the former herd which became universally tuberculous, and, even under the crucial test of the tuberculin, furnished not a single case of tuberculosis. The only difference is that with the present herd intelligent measures were taken to exclude the germ of the tuberculosis. The case is all the more striking that some of the most important precautions against the spread

of tuberculosis in a herd were not put in force. The cows were not taught to keep the same stall on all occasions, but went into any stall that was convenient. Then there were no partitions between the feeding places of adjacent stalls and one cow could lick up the food from the two stalls on the right and left as well as from her own. With an infecting cow in the herd, therefore, there was every opportunity for a speedy spread of the infection. In spite of such obvious opportunity for infection the careful selection of the first members of the present herd, the building up of the herd by home breeding only, and the weeding out of all suspicious animals succeeded in excluding any trace of tuberculosis.

The experiment, however, entailed the entire destruction of the original infected herd, and though the post mortem examination showed that in this instance this step was necessary to a successful result yet in many other less universally diseased herds the larger part could have been saved by picking out the diseased with the aid of the tuberculin test.

2d. In Cornell University herd, which numbers about sixty cattle, old and young, tuberculosis led to the destruction of a number of individuals. The diseased, however, were disposed of as soon as objective symptoms showed the presence of tuberculosis, and after some years of this weeding out when I tested the whole herd with the newly discovered tuberculin I could find no trace of the disease except in a young bull which had recently been acquired from another herd. Since his destruction I have tested them repeatedly, but have found no trace of tuberculosis.

EXTINCTION OF TUBERCULOSIS WITH THE AID OF TUBERCULIN.

If a herd has been bred up from home stock without the introduction of any animal from without, and if for a number of years there have been no losses and no illness suggestive of any form of tuberculosis there is a fair presumption that it is free from that disease. But in the average herd, and especially if sickness or death has occurred, even if such has been attributed to something else, it is a wise precaution to subject the whole

to the tuberculin test. Especially now when the N. Y. State Veterinary College undertakes to furnish tuberculin free for use in herds in this state, the expense of such a test should not be a serious drawback. The measures to be adopted may be thus enumerated.

1st. Apply the tuberculin test to the entire herd.

2d. Remove all animals showing a rise of temperature which indicates tuberculosis.

3d. Destroy and burn, boil, or deeply bury all cases of the disease, unless it is decided to form an isolated herd of latent cases which are in good condition. (See above.)

4th. In case of doubt or disturbing influences which may have caused rise of temperature (nearness to calving, heat, exposure, concurrent disease, changes in management, etc.), keep the suspected animal apart for three or four weeks and test again. This will almost certainly correct any mistake of the first test.

5th. Repeat the test every three months and if two successive tests show no indication of tuberculosis the herd may be accounted safe.

6th. As soon as tuberculous animals have been removed from a stable let it be vacated and thoroughly disinfected with chloride of lime, 4 ounces to a gallon of water and enough quicklime to make a good whitewash, which will show if even a square inch has been missed. When chloride of lime is objectionable because of its tainting the milk, mercuric chloride may be used in the proportion of one drachm to a gallon of water, to which is added one drachm of sal ammoniac and 5 drachms of common salt. This is much more poisonous than the chloride of lime and must be cautiously handled during its application. The walls, roof, and especially the floor, gutter and feeding trough must be first thoroughly scraped, washed and cleaned, all rotten woodwork must be removed, and in case of double boarded walls, the boards must be removed on one side to permit of a thorough application.

7th. In making new purchases avoid any herd in which tuberculosis has appeared, or which has had sickness or deaths in recent years.

8th. Don't purchase from city, suburban nor swill stables.

9th. Don't take a cow which is in ill health or low condition, especially one with cough, nasal discharge, foul breath, hard nodules under the skin, diseased udder, swollen loins or joints or a tendency to scour or bloat.

10th. Test every fresh animal with tuberculin before admitting it to your herd, unless it has been recently tested and has not since been exposed to possible infection.

11th. Don't admit strange cattle to house, field or yard with your own. Keep them apart until tested with tuberculin.

12th. Keep each animal in your herd strictly to its own stall and manger.

13th. Board up the partitions of the stalls in front so that no two cows can feed from the same manger nor lick each other.

14th. Be especially observant of the older cows and on the slightest sign of ill health separate and subject to the tuberculin test.

15th. In case a herd of cattle is found to be tuberculous subject to the tuberculin test all the domestic animals that have mingled with them freely and fed from the same troughs. Remove those that show a reaction.

16th. Exterminate the vermin (rats, mice, sparrows) in a building where tuberculosis has prevailed.

17th. Let no consumptive person attend on cattle or other live stock, nor prepare their food.

EXTINCTION OF TUBERCULOSIS BY STATE ACTION.

It is out of the sphere of the private breeder or dairyman to enter on the question of state sanitary police, yet no one is more deeply interested in the general enforcement of such measures as would banish the existing dangers which attend on the purchase of strange animals and their products. In recent years the rigid supervision of herds in the New England States has driven many infected cattle into New York to spread tuberculosis in previously healthy herds, and to increase it in those that were already affected.

The exclusion of cattle seeking to enter Pennsylvania or the New England States, which were not accompanied by the certificate that they had successfully stood the tuberculin test, has

led to the testing of western cattle at Buffalo, Albany and elsewhere, and the detention of such as failed under the test, to be sold too often to the unsuspecting New York stockowner. The tests have often been made by the inspectors of the Bureau of Animal Industry, who have no legal right to interfere with the condemmed cattle unless the attempt is made to move them into another state, and in the absence of any restriction by the municipal or state health officers, the owner or dealer is at liberty to sell such tuberculous cattle in open market.

If the test is made by a veterinarian who is not a national nor state official the same holds true ; he has no authority to forbid the sale of the diseased and condemned cattle.

Again, private stockowners have had their own herds tested, and have removed from the herd those that failed to stand the test, but there is nothing to show what became of such condemned animals, and in the absence of a state indemnity and slaughter, there is much to be suspected.

These are hints of the evils that have been precipitated for a length of time upon our New York live stock industry. Day by day our herds are being systematically infected by the introduction of the tuberculous offscouring of other states and of our own, and we raised not a finger to stop it.

Further, in the interests of the consuming public we have to consider that we have no inspection in our little local abattoirs and no guarantee of the meats there killed. And meanwhile we are giving free rein to every evil disposed dealer, to add to our herds the tuberculous animals drawn from the states around us.

The crying need of New York to-day is first to block these streams of infection, which are now practically invited into our herds from other commonwealths, and second to inaugurate a systematic effort to rid our own herds, which are the sources of our dairy and meat products from this scourge.

The Following Bulletins are Available for Distribution to Those Who may Desire Them.

39 Creaming and Aerating Milk, 20 pp,
40 Removing Tassels from Corn, 9 pp.
41 Steam and Hot-Water for Heating Greenhouses. 26 pages.
49 Sundry Investigations of 1892, 56 pp.
53 Œdema of the Tomato, 34 pp.
55 Greenhouse Notes, 31 pp.
58 Four-Lined Leaf-Bug, 35 pp.
61 Sundry Investigations of the Year 1893, 54 pp.
64 On Certain Grass-Eating Insects, 58 pp.
69 Hints on the Planting of Orchards, 16 pp.
71 Apricot Growing in Western New York, 26 pp.
72 The Cultivation of Orchards, 22 pp.
73 Leaf Curl and Plum Pockets, 40 pp.
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75 Peach Yellows, 20 pp.
76 Some Grape Troubles in Western N. Y., 116 pp.
77 The Grafting of Grapes, 22 pp.
78 The Cabbage Root Maggot, 99 pp.
79 Varieties of Strawberry Leaf Blight, 26 pp.
80 The Quince in Western N. Y., 27 pp.
81 Black Knot of Plums and Cherries, 24 pp.
82 Experiments with Tuberculin, 20 pp.
84 The Recent Apple Failures in N. Y., 24 pp.
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92 Feeding Fat to Cows, 15 pp.
93 Cigar- Case-Bearer, 20 pp.
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96 Forcing House Miscellanies, 43 pp.
97 Entomogenous Fungi, 42 pp.
100 Evaporated Raspberries in New York, 40 pp.
101 The Spraying of Trees and the Canker Worm, 24 pp.
102 General Observations in Care of Fruit Trees, 26 pp.
103 Soil Depletion in Respect to the Care of Fruit Trees, 21 pp.
104 Climbing Cutworms in Western N. Y. 51 pp.
105 Test of Cream Separators, 18 pp.
106 Revised Opinion of the Japanese Plums, 30 pp.
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117 Fruit Brevities, 50 pp.
119 Texture of the Soil, 8 pp.
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122 Second Report upon Extension Work in Horticulture, 36 pp.
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124 The Pistol-Case-Bearer in Western New York, 18 pp.
125 A Disease of Currant Canes, 20 pp.
126 The Currant-Stem Girdler and Raspberry-Cane Maggot, 22 pp.
127 A Second Account of Sweet Peas, 35 pp
128 A Talk about Dahlias, 40 pp.
129 How to Conduct Field Experiments with Fertilizers, 11 pp.
130 Potato Culture, 15 pp.
131 Notes upon Plums for Western New York, 31 pp.
132 Notes upon Celery, 34 pp.
133 The Army-Worm in New York, 28 pp.
134 Strawberries under Glass, 10 pp.
135 Forage Crops, 28 pp.
136 Chrysanthemums, 24 pp.
137 Agricultural Extension Work, sketch of its Origin and Progress, 11 pp.
138. Studies and Illustrations of Mushrooms: I.
139. Teird Report upon Jananese Plums.
140. Second Report on Potato Culture.
141. Powdered Soap as a Cause of Death Among Swill-Fed Hogs.
142. The Codling-Moth.
143. Sugar Beet Investigations.
144. Suggestions on Spraying and on the San José Scale.
145. Some Important Pear Diseases.
146. Fourth Report of Progress on Extension Work.
147. Fourth Report upon Chrysanthemums.
148. The Quince Curculio.
149. Some Spraying Mixtures.

Bulletins Issued Since the Close of the Fiscal Year, June 30, 1898.

150. Tuberculosis in Cattle and its Control.

Bulletin 151. **August, 1898.**

Cornell University Agricultural Experiment Station,

ITHACA, N. Y.

AGRICULTURAL DIVISION.

Gravity or Dilution Separators.

APPROVED BY THE COMMISSIONER OF AGRICULTURE,
UNDER CHAP. 67, LAWS OF 1898.

By H. H. WING.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1898.

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The regular bulletins of the Station are sent free to all who request them.

GRAVITY OR DILUTION SEPARATORS.

Several years ago, before the general introduction of separators, when the deep setting gravity system of raising cream was the method in common use in the larger butter making districts, there occurred in New England and New York a succession of very mild winters when the supply of ice, so necessary in the deep setting systems, was very materially reduced and, in some cases, entirely cut off. To overcome the lack of ice it was suggested that the raising of the cream could be facilitated by diluting the milk with from one half to an equal volume of water, and the claim was freely made that the separation was then as complete as though the milk without dilution had been set in ice water. The whole matter was quite thoroughly investigated by several experiment stations,* and the following general conclusions quoted from the Cornell University Agricultural Experiment Station Bulletin 39 have since been pretty generally received as authoritative :

"Combining the results of this Station with the results at the Vermont Station, we have the following average percentages of fat in the skimmed milk under the different systems :

Diluted,	set at 60°	(39 trials)	.77%
Undiluted,	set at 60°	(30 trials)	1.00
Undiluted,	set at 40°	(26 trials)	.29

"It would seem therefore that while, when the milk is set at sixty degrees or thereabouts, there is considerable advantage, so far as the efficiency of creaming is concerned, in diluting it with 25 per cent of warm water ; this dilution cannot be regarded as a substitute for setting without dilution in ice water, and it has

*Vermont Agr. Expt. Sta., Newspaper Bulletin No. 3 and 4th Annual Report, pp. 100-107.

Cornell Univ. Agr. Expt. Sta., Bulletins Nos. 20, 29 and 39.

University of Illinois Agr. Expt. Sta., Bulletin No. 12, p. 376 and Bulletin No. 18, p. 30.

the further disadvantage of requiring increased tank capacity and producing a rapidly souring cream."

It might be added that the diluted skimmed milk is very materially lessened in value for feeding purposes.

Within the past year or year and a half numerous letters have been received making inquiries into the merits of so called "dilution" or "gravity" separators. Since the early spring of this year these inquiries have been much more frequent and it finally seemed worth while to make a somewhat careful trial of the merits of these "separators." So far as is known, the attention of the public has not been called to these "separators" through the agricultural or dairy press by advertisement or otherwise, and they have been introduced almost wholly by retail agents travelling through those sections where only small herds of cows are kept and where the old shallow pan system of creaming is still in use. (Circulars of two of these "separators" finally came into our hands and a representative of the station bought one of the smaller sizes of each kind direct from the manufacturers.) They are known respectively as "Wheeler's Gravity Cream Separator" made by the Gravity Cream Separator Co., Mexico, N. Y., and "Hunt's Improved Ventilated Cream Separator" made by the Hunt Manufacturing Co., Cato, N. Y. Another known as the "Aquatic Cream Separator" made by the Aquatic Cream Separator Co., Watertown, N. Y., has been sent us for trial, and there may be still others on the market.

The somewhat extravagant claims made for these "separators" are best shown by quoting from the circulars and directions sent out with the machines as follows:

"WHEELER'S GRAVITY CREAM SEPARATOR.

"A new device to separate cream from milk by the dilute process, which reduces the viscosity of the milk, thereby securing the cream in two hours. No ice to handle, no cranks to turn, no machinery to run and keep in order.

"It is way ahead of the best creamery, being the *cheapest*, *best* and *easiest* device to handle milk on the market, and you will make no mistake if you investigate its merits.

"VISCOSITY.

"There is a property in milk called viscosity. It is caused by the solids in milk aside from the butter fat. It is a sort of stickiness that retards the raising of the cream. By proper dilution with water we can so reduce this viscosity that the cream will separate or rise in two hours. And, on the same principle, anything that will help the cream up quickly, will also help it to come up thoroughly, therefore we claim we get cream, not only much quicker, but cleaner than with the creamery.

"WE TAKE OUR OWN MEDICINE.

"Have used the *Gravity Cream Separator* in our own dairy the past season to the satisfaction of ourselves and our customers, who pay us an extra price for our butter. Every dairyman that makes butter should use the *Gravity Cream Separator*, and every one that takes their milk to the cheese factory should use it spring, fall and Sundays.

"Those that keep only one or two cows, as well as the large dairyman, can have the advantage of a separator at a small cost, compared with the centrifugal separator or creamery.

"IMPORTANT THINGS TO THINK ABOUT.

"In these times of low prices how can we reduce cost of production?

"First. In handling our milk we can reduce the first cost several hundred per cent over any other device by using the *Gravity Cream Separator*.

Second. It does away with *storing*, *handling* and *cost* of ice.
Third. It saves more than half the work.
Fourth. It is easy to wash and keep clean.
Fifth. It runs itself.
Sixth. It is durable, being well made of heavy tin.
Seventh. It makes ladies happy.
Eighth. It is endorsed by the Grange.
Ninth. Practical dairymen give up their creameries to use the *Gravity Cream Separator*.

"Sizes made to fit any dairy from one cow up. State the number of pounds of milk you have to separate per day and we will quote prices.

"STARTLING FACTS,

"Brought to light from the experience of practical dairymen the past season, have shown that the diluted sweet milk from the

Gravity Cream Separator is superior for feeding purposes to the undiluted sour milk from pan system. And many claim it is better than the milk from the Centrifugal Separator. This may look like a bold assertion, but it is easily explained.

"THE REASON WHY.

"The solids left in the milk after the butter fat is extracted are what give the feeding value to the skimmed milk. The Gravity Cream Separator leaves these solids in the milk, but the Mechanical Separator, by its great speed, collects these solids and deposits them in the bowl of the Separator in the form of ropy, sticky and offensive substance made offensive by the great speed and friction in the bowl of the machine.

"WHEELER'S GRAVITY CREAM SEPARATOR.

"U. S. AND FOREIGN PATENTS PENDING.

"*Directions for Using the Gravity Cream Separator.*

"Place the Separator on a bench or box in any convenient place, with the front projecting over a little, so that a pail can be placed under the faucet without disturbing the Separator when drawing off the milk and cream. Place over the top of the Separator two or three thicknesses of cheese cloth, and fasten with the wire strainer holder. Pour the milk from a strainer pail through the cloth, then dilute with as much good well water as you had of milk. Stir till well mixed. With Jersey, or any rich milk, use more water. In fact, you can't hurt the cream or butter with water, for water and butter fat will not mix, and water absorbs impurities and taints in milk, thereby improving the quality of the butter.

"In very cold weather, if the milk gets cooled off before it is taken to the house, add enough warm water to it to bring it up to 90 degrees, or 100 degrees, before it is put in the Separator; then put in Separator and dilute with cold water as per directions. Remove the strainer cloth and replace with mosquito netting to keep out flies and give plenty of ventilation. Any time after two or three hours, or between milkings, you can draw off the milk and cream. Partly close the faucet when the cream shows in lower gauge. Keep the cream in a cool, sweet place and stir often till you have enough for churning, then warm up to 65 to 70 degrees, and keep 12 to 24 hours to ripen. Churn at 60 to 62 degrees in summer, and 65 to 70 degrees in winter. Davis Swing or Barrel churn best for Separator cream. The

churn should be less than half full of cream for quick time in churning.

Be sure and have the cream well ripened. If the Separator is rightly managed you will get all the cream, and if the cream is rightly handled you will get all the butter."

The following is the description and directions for using Hunt's Improved Ventilated Cream Separator:

"TO THE PUBLIC.

"Hunt's Improved Ventilated Cream Separators have been on the market for nearly a year. They are now no experiment, having been subjected to the most critical experiments and have fully demonstrated themselves as the most perfect device for separating cream from milk. We have placed them before Farmers' Institutes in this State, also Michigan, Ohio and Nebraska, and they were endorsed by them as the best and cheapest labor saving device for making butter ever put on the market.

"HUNT'S IMPROVED VENTILATED CREAM SEPARATOR.

"A new device to separate cream from milk by a dilute process, which reduces the viscosity of the milk, thereby securing all the cream in a few hours. It is far ahead of the best creamery, being the cheapest and easiest device to handle milk.

"VISCOSITY.

"There is a property in milk called viscosity. It is caused by the solids in milk aside from the butter fat. By proper diluting with water we can so reduce this viscosity that the cream will separate and raise in one or two hours, and on this principle anything that will help the cream to raise quickly will also help it raise thoroughly. We claim to get the cream not only quicker but cleaner than by any other method when using our Ventilated Cream Separator. Your butter is sweeter, harder and much better than the old method when using pans. Every dairyman should use the Improved Ventilated Cream Separator. It will work as well in winter as in summer, and can be placed in any convenient place near the well or kitchen pantry, etc. Those that keep only one or two cows, as well as large dairymen, can have the advantage of a Separator at a small cost compared with the centrifugal separators or creameries.

"IMPORTANT TO DAIRYMEN.

"In these times of low prices of butter, how can we reduce the cost of production?

1st. In handling our milk we can so reduce the cost one hundred per cent by using Hunt's Improved Ventilated Cream Separator.

2d. It does away with the cost of handling and storing ice.

3d. It saves more than half the labor.

4th. It is easy to keep clean and sweet.

5th. It runs itself; no crank to turn, no machinery to get out of order.

6th. It is ahead of any separator on the market, and made from the best brands of XXX charcoal tin, such as we used to get years ago.

7th. It is the only and original cream separator on the market with inside ventilation, thereby saving one-third more cream.

8th. Practical dairymen give up their creameries to use the Hunt's Improved Ventilated Cream Separator, as it requires *no ice* and gives the same satisfaction.

9th. It is endorsed by Farmers' Institutes, the Grange and all other professional butter makers.

10th. Don't try a separator until you have tried ours. We lead; others try to follow. Be sure that your separator has an inside tube for ventilation. All others are an infringement, and you will have to pay a royalty for using any other.

"*Directions for Using Hunt's Improved Ventilated Cream Separator.*

"PATENT APPLIED FOR.

"Place the separator on a shelf or box, the front of can projecting far enough to place a pail under the faucet without disturbing the can when drawing off the milk and cream. Place over the top of the can two thicknesses of cheese cloth and fasten with the wire strainer holder. Pour the milk from strainer pail through the cloth, then add to the milk the same amount of water at 50 or 60 degrees. Mix both together stirring it for a few moments. Remove the cheese cloth from top and replace a piece of mosquito netting to keep out flies and other insects. After three or four hours setting it will be ready to draw off the cream. Partly close faucet when cream shows in lower gauge. When about one inch of milk remains to be seen in gauge close faucet and then draw balance of milk and cream in a separate dish. Keep the cream in a cool place until there is enough for churning, then warm the cream to 65 or 70 degrees. Twelve to twen-

ty-four hours is necessary to ripen. Churn at 62 degrees in warm weather and 65 degrees in winter. We guarantee one-third to one-half more cream by using this separator than from any other on the market."

The "machines," as shown by the cut on the title page, are simply tin cans fitted with upper and lower scale glasses, a faucet at the bottom through which the skimmed milk is drawn off and a wire ring at the top for holding a strainer cloth or cloth cover. Hunt's has in the middle of the can a narrow tin tube, open at the top and bottom, which constitutes the ventilating feature of the apparatus.

There is absolutely nothing new about these cans. They are entirely similar in all essential features to the cans used in the various deep setting gravity cream raising processes, as the Cooley, Moseley and others. Even the ventilating tube is not a new device. So far as is known neither is patented although "Patent is applied for" in the case of each, and the circulars of Hunt's give strong warnings as to infringement.

Attention is called to the way in which the term separator is used in the name of these cans and in the descriptive matter concerning them. As is well known, there are two forces used to separate cream from milk; the force of gravity acting upon a mass of milk at rest in a suitable vessel, and centrifugal force acting upon milk in motion in a rapidly revolving cylinder or bowl. By common and universal consent the machines separating milk in this latter way are alone known as cream separators, and while it is certainly strictly true that any apparatus in which cream is separated from milk may be called a cream separator, it is as certainly misleading to apply the term cream separator to any other than a centrifugal separator. An old-fashioned shallow pan is just as much and just as truly a "cream separator" as are these cans. It is plainly evident in the above circulars, though it is not distinctly so stated, that the idea is intended to be conveyed that these are separators similar, at least in efficiency, to centrifugal separators.

THE AQUATIC SEPARATOR.

This apparatus (Fig. 6) made by the Aquatic Cream Separator Co., Watertown, N. Y., only differs from the others in the fact that the can is of considerably larger diameter and is provided with another smaller can intended to be filled with ice and inserted in the large can as a cooler. The descriptive circulars and printed directions are strikingly similar to those of Wheeler's and Hunt's and many of the same phrases are employed. In fact, the same company send out a can, intended to be used with-

6.—*The Aquatic Separator.*

out the central ice can, that is entirely like Wheeler's except that it is slightly taller. The Aquatic Cream Separator was patented on June 7, 1898, and on consulting the *Official Gazette* of the United States Patent Office, Volume 83, No. 10, June 7, 1898, it was found that on that date a patent was granted as follows:

"605252. Apparatus for separating cream from milk, Chester L. Lee, Ellisburg and Frederick G. Lee, Pierrepont Manor, N. Y. Filed Sept. 13, 1897. Serial No. 651,446. (No model.)

"*Claim*—An apparatus for separating cream from milk comprising a milk can provided with a centrally depressed bottom and

having an outlet in the center of said bottom, a cooler within said can and provided on its bottom with feet supporting the cooler over said outlet with passages under the cooler, said feet serving to prevent eddying of the outflowing liquid and causing a draft of said liquid equally from all sides of the can to the outlet and also promoting the discharge of the sediment from the bottom of the can substantially as described."

It will be seen that the claim for the patent is based upon the outlet of the large can which is "centrally depressed and at the center" and in the construction of the legs or supports on the bottom of the cooler. In the can received by us from the company, the outlet is not in the center but at the side, and the cooler, without any legs or supports whatever, is made to set flat upon the bottom of the larger can. It would seem as though the patent must be regarded, even by the company, as of practically no value.

PRACTICAL TRIALS.

All three of these "Separators" have been used according to the directions. The room in which the cans were set was at a temperature of 65-75 degrees. The water used was at a temperature between 50 and 60, and in all cases the cans set rather more than twelve hours before they were skimmed. They were skimmed by drawing the mixture of skim milk and water from the bottom till the cream line was within one inch of the bottom of the can. The fat in this skim milk and water was determined by the Babcock Test, and then correcting for the water added, the percentage of fat in the skimmed milk and water was secured.

The milk used was, at first the mixed evening's milk of the University herd and it was set as soon as milked and taken to the dairy. Many of the cows were in advanced lactation and giving small amounts of milk, and it was found that it creamed very imperfectly though we had been having no difficulty at all in skimming it perfectly clean with the centrifugal separator. For the later trials the milk of a few cows fresh within two or three months was reserved so that the trials have included milk that is representative of all milk likely to be found on farms.

In all the trials made with Hunt's and Wheeler's cans comparisons were made with Cooley cans set in ice water without dilution. The trials with the Aquatic were made later with milk from the same cows, but no comparisons were made with the Cooley. The results are shown in the tables following:

TABLE I. MIXED HERD MILK. MANY OF THE COWS NEARLY DRY.

Date.	Number of hours set.	Per cent fat in whole milk.	Wheeler's. Pounds milk.	Temperature.	Pounds water.	Temperature.	Temperature when skimmed.	Per cent fat in skim milk.	Hunt's. Pounds milk.	Temperature.	Pounds water.	Temperature.	Temperature when skimmed.	Per cent fat in skim milk.	Cooley. Pounds milk.	Temperature.	Temperature when skimmed.	Per cent fat in skim milk.
July 6.....	14	3.95	30	92	30	53	70	.76	25	92	25	53	69	.66	33½	92	42	.90
" 7	14½	4.1	25	86	25	56	72	.86							53	86	40	1.25
" 8.....	15	3.6	25	94	25	50	72	1.00							35	94	38	.80
" 9....	12	3.9	20	88	20	48	66	1.00	25	88	25	48	68	1.00	28	88	42	1.20
" 11.....	17	3.6	20	92	20	56	64	1.20	28	92	28	56	64	1.00	20	92	44	1.00
" 12.....	16	3.6	20	87	20	47	63	.80	28	87	28	47	65	1.40	34	87	38	.90
			Average					.94	....					1.01	....			1.01

TABLE II.—MILK FROM COWS COMPARATIVELY FRESH.

Date.	Number of hours set.	Per cent fat in whole milk.	Wheeler's. Pounds milk.	Temperature.	Pounds water.	Temperature.	Temperature when skimmed.	Per cent fat in skim milk.	Hunt's. Pounds milk.	Temperature.	Pounds water.	Temperature.	Temperature when skimmed.	Per cent fat in skim milk.	Cooley. Pounds milk.	Temperature.	Temperature when skimmed.	Per cent fat in skim milk.
July 13.....	16½	3.75	20	94	20	56	70	.90	28	94	28	56	70	1.40	33	94	40	.50
" 14.....	16	3.7	20	94	20	55	72	.80	28	94	28	55	72	.80	33	94		.50
" 15.....	16	3.75	20	94	20	54	72	.40	28	94	28	54	72	.40	33	94	40	.60
" 16.....	16½	3.8	20	94	20	60	70	.60	28	94	28	60	71	.40	34	94	37	.50
" 17.....	16	4.	20	95	20	50	73	1.00	28	95	28	50	73	.90	37	95	38	.65
" 18.....	16	3.9	20	96	20	48	75	.90	28	96	28	48	75	1.90	34	96	42	.50
" 19.....	16	3.65							36	96	28	58	76	1.00	38	96	40	.50
" 20.....	16	3.45							30	95	30	54	74	.60	34	95	41	.40
" 21.....	15½	4.1	20	94	20	58	75	.90							35	94	44	.65
			Average					.79	....					.93	....			.53
			Average both tables.....					.86	....					.96	....			.72

TABLE III. MILK FROM COWS COMPARATIVELY FRESH.

Aquatic Cream Separator.								
Date.	No. of hours set.	Per cent fat in whole milk.	Pounds milk.	Temp.	Pounds water.	Temp.	Temp. when skimmed.	Per cent fat in skim milk.
July 27.	15	3.25	50	96	50	52	66	.60
July 29.	15	3.3	45	94	45	44	62	.80
July 31.	15	3.4	37	94	37	50	56	.50
Aug. 1.	15½	3.1	54	93	54	50	61	.70
Aug. 3.	15½	3.8	61	94	61	44	62	.50
							Average.....	.62

We have also taken occasion to test several of these cans in actual use by farmers in this and adjoining counties. In all, five different places were visited and four or five tests made at each place. The cans were all of the same form as Wheeler's, that is, plain cans without ventilators or coolers. The milk was set about twelve hours and was at a temperature, when skimmed, of from 68 to 70 degrees. The whole milk contained from 4 to 5 per cent of fat and was largely the milk of Jersey and Jersey grade cows. Equal parts, by measure, of milk and water were used. The results were as follows :

TABLE IV. TESTS AT FARMS.

Farm No. 1.		Farm No. 2.		Farm No. 3.		Farm No. 4.		Farm No. 5.	
Date.	Per cent fat in skimmed milk.	Date.	Per cent fat in skimmed milk.	Date.	Per cent fat in skimmed milk.	Date.	Per cent fat in skimmed milk.	Date.	Per cent fat in skimmed milk
July 14 a. m.	1.00	July 25 a. m.	1.10	July 25 a. m.	.90	July 25 a. m.	1.00	July 25 a. m.	1.20
" 14 p. m.	.30	" 25 p. m.	1.10	" 25 p. m.	1.00	" 25 p. m.	.90	" 25 p. m.	1.50
" 15 a. m.	.50	" 26 a. m.	.90	" 26 a. m.	.80	" 26 a. m.	.80	" 26 a. m.	1.00
" 15 p. m.	.90	" 26 p. m.	.80	" 26 p. m.	.80	" 26 p. m.	.90	" 26 p. m.	1.10
" 16 a. m.	.60	" 27 p. m.	1.10	" 27 p. m.	1.00	" 27 p. m.	.90		
Average....	.66	Average....	1.00	Average....	.90	Average....	.90	Average....	1.20

Before calling attention to these tables in detail, a few words of explanation as to what is meant by efficient creaming may be of service in helping to a clear understanding of the whole matter. The separation of cream from milk is always attended by the loss of some fat which remains in the skimmed milk. The less this fat is, the more efficient the creaming and *vice versa*. The percentage of fat in the skimmed milk is therefore the most convenient measure of the loss that has occurred in any process of separation.

Centrifugal separators have been so perfected that the loss of fat in the skimmed milk is reduced to a minimum, and for several years it has been recognized by both manufacturers and users of separators that the percentage of fat in the skimmed milk need not be more than .1 of 1 per cent, and in actual practice it is found that there is seldom more than .2 of 1 per cent in the skimmed milk. When a gravity process, either deep or shallow setting, is used the percentage is larger and considerably more variable. When the conditions are all favorable the efficiency, particularly of the cold deep setting, approaches the centrifugal separator, but it is not infrequently in gravity creaming to find one per cent or more of fat in the skimmed mllk.

In the summer of 1892 seventy farms were visited and the fat determined of the skimmed milk at each place. On forty of these farms shallow pans were used and on thirty a deep setting system, in most cases the Cooley, was in operation. The average results were as follows:

	Per cent of fat in skimmed milk.		
	Lowest.	Highest.	Average.
Forty farms using shallow pans	.15	1.63	.39
Thirty farms using deep setting	.14	.60	.30

We are now able to judge of the efficiency of these gravity cans. It will be seen that in no case do they approach anywhere near the efficiency of the centrifugal separator and, in most cases, the percentage of fat in the skimmed milk is decidedly more than would be called good creaming by either the shallow pan or deep setting process. In table I where "stripper" milk is used they show an average efficiency about equal to the Cooley, but where the milk of fresher cows were used (Table II) the Cooley gave distinctly better results. The tests made at the various farms

show rather higher percentages of fat in the skimmed milk than were obtained here and give a fair idea of the results likely to be obtained under ordinary farm conditions.

CONCLUSIONS.

Gravity or dilution separators are merely tin cans in which the separation of cream by gravity process is claimed to be aided by dilution with water.

Under ordinary conditions the dilution is of no benefit. It may be of some use when the milk is all from "stripper" cows, or when the temperature of melting ice cannot be secured. (C. U. Agr. Exp. Sta. Bull 39.)

These cans are not "separators" in the universally accepted sense of that term and cannot rank in efficiency with them.

They are even less efficient than the best forms of deep setting systems, such as the Cooley Creamer.

They are no more efficient than the old fashioned shallow pan; but perhaps require rather less labor.

In all probability they would give better results if used without dilution and immersed in as cold water as possible, preferably ice water.

THE FOLLOWING BULLETINS ARE AVAILABLE FOR DISTRIBUTION TO THOSE WHO MAY DESIRE THEM.

39 Creaming and Aerating Milk, 20 pp.
40 Removing Tassels from Corn, 9 pp.
41 Steam and Hot-Water for Heating Greenhouses. 26 pages.
49 Sundry Investigations of 1892, 56 pp.
53 Œdema of the Tomato, 34 pp.
55 Greenhouse Notes, 31 pp.
61 Sundry Investigations of the Year 1893, 54 pp.
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136 Chrysanthemums, 24 pp.
137 Agricultural Extension Work, sketch of its Origin and Progress, 11 pp.
138. Studies and Illustrations of Mushrooms: I.
139. Third Report upon Japanese Plums.
140. Second Report on Potato Culture.
141. Powdered Soap as a Cause of Death Among Swill-Fed Hogs.
142. The Codling-Moth.
143. Sugar Beet Investigations.
144. Suggestions on Spraying and on the San José Scale.
145. Some Important Pear Diseases.
146. Fourth Report of Progress on Extension Work.
147. Fourth Report upon Chrysanthemums.
148. The Quince Curculio.
149. Some Spraying Mixtures.

Bulletins Issued Since the Close of the Fiscal Year, June 30, 1898.

150. Tuberculosis in Cattle and its Control.
151. Gravity or Dilution Separators.

Bulletin 152. **October, 1898.**

Cornell University Agricultural Experiment Station,

ITHACA, N. Y.

AGRICULTURAL DIVISION.

STUDIES IN MILK SECRETION

DRAWN FROM

OFFICIALLY AUTHENTICATED TESTS

OF

HOLSTEIN-FRIESIAN COWS.

By HENRY H. WING and

LEROY ANDERSON.

PUBLISHED BY THE UNIVERSITY.
ITHACA, N. Y.
1898.

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STUDIES IN MILK SECRETION.

In 1894, in response to inquiries from several Breeder's Associations, the Cornell University Agricultural Experiment Station agreed to send an authorized representative to supervise the milk and butter records of thoroughbred cows for any one desiring such records made, upon conditions laid down by the Station. Thus far there has been but little call for supervisors of such tests, except among members of the Holstein-Friesian Association of America. In fact, there has been but one seven-day test made of cows of any other breed. In 1885, this association adopted a set of rules establishing what is known as a system of Advanced Registry, into which no cow is allowed to be entered until she has made a certain record for milk or butter production, the amount of this record depending upon her age. The wisdom of adopting such a system has been attested by the uniform success attending the carrying out of its provisions, and in 1894, the Association added another and still more valuable feature, consisting of what are called "Officially Authenticated Butter Records." For these records prizes amounting to about $1,300.00 are given annually. "Such records must be for seven consecutive days and must be supervised by an officer of some Experiment Station or State institution, or by the Superintendent of Advanced Registry or some inspector designated by him." The rules also provide "that such records may be made by the churn or by the Babcock test, or by any other method approved by the Association of Official Agricultural Chemists." The Babcock test, however, owing to its simplicity and accuracy has been universally adopted as the means for determining the amount of butter fat produced, from which the equivalent butter is calculated. It has also been the almost universal custom among breeders to look to the Experiment Stations for supervisors of tests. The first year, however, that of 1894, of the twenty-five official records published from tests made in New York State

only four were supervised by representatives from this Station. On the other hand, during the succeeding years all but three of the official records published from this State have been supervised by representatives from this Station. The men who have supervised these tests are Professors H. H. Wing and G. C. Watson, and Messrs. J. M. Trueman, S. H.T. Hayes, R. L. Speed, J. M. Johnson, Horace Atwood, Hugh C. Troy, A. R. Ward, H. C. McLallen and Leroy Anderson. It is only from data obtained by our representatives while conducting these official tests that we have to deal in this bulletin.

The method of conducting an official test is briefly as follows: The person supervising sees the cow or cows milked dry before the beginning of the test and is present at each milking thereafter until each test is completed; he weighs the milk of each cow separately, samples the same and makes a determination of the butter fat by the Babcock test. He keeps a careful record of each milking, with its per cent and amount of butter fat, and in his report of the test must make an affidavit to the accuracy and truthfulness of the same. The supervisor also keeps a record of the kinds and amount of food eaten by each animal during the test. The cows are wholly under the control of the owner so far as kind and amount of food, time of milking and general treatment are concerned, but the person making the test has access to the cows at all times in company with the owner or his representative. The owner furnishes a statement of the name and herd book number of the cow, her age and the time at which she dropped her last calf. It is from data obtained in the above manner that the tables contained in the following pages are compiled.

The first tests of Holstein-Friesian cattle conducted by representatives from our Station were begun on May 30th, 1894, and such tests have occurred at various intervals up to the present time. Eight different herds have been visited and 210 separate tests been made of 153 different animals. Some animals have been tested twice and one as many as six times. From these tests and the vast amount of data so accumulated, we believe that something of interest and value can be deduced for the general dairyman as well as for the breeder of Holstein-Friesian cattle.

From such a mass of material it is difficult to glean the more important points and place them in digestible form before the general reader ; but we have attempted to draw out those points that appear of most scientific and practical importance to the student, breeder and dairyman, and to place them in as readable form as possible. With so much data at hand it is natural to make many tables, but we have endeavored to eliminate all such as show figures merely and to present only those which teach some lesson or from which some practical conclusion can be drawn.

All records contained in the following tables were made from tests continuing for seven consecutive days. In these records we have given the amount of pure butter fat produced but not its equivalent in marketable butter. According to the rule adopted by the Holstein-Friesian Association .80 of a pound of fat is considered equivalent to one pound of butter, while the Association of American Agricultural Colleges and Experiment Stations has adopted .85$\frac{5}{7}$ of a pound of fat as equivalent to one pound of butter. If one-fourth of the fat be added to itself in the former case or one-sixth in the latter, the fat may be readily and quickly converted to its equivalent amount of butter, e. g., 18 pounds of fat would be equivalent to 22½ pounds of butter according to the former and 21 pounds according to the latter. The average per cent of fat is obtained by dividing the total amount of fat by the total amount of milk produced in the seven days.

In Table I is given the name and herd book number of the the cow, her owner, age at the time of calving, date of beginning the test, number of days from calving to the beginning of the test, pounds of milk for the seven days, average per cent of fat and total pounds of fat for the seven days. The records of the cows are arranged in Tables I and II, (1) according to age, two-year olds coming first, then the three and four year olds, and full aged cows following successively. (All cows five years old or over are considered as of full age.) (2) Under each age, in the order of time in which the cows were tested, beginning with the first test on May 30th, 1894, and continuing in order until the last test on June 25th, 1898. For convenience of reference,

each of the records is given a number, which number appears in the column to the left of the cow's name under head of "Number of Test." These numbers begin with the first two-year old test and run consecutively through the various ages of the animals. The two-year olds include numbers 1 to 74, three-year olds 75 to 112, four-year olds 113 to 147 and full aged cows 148 to 210. Thus of the 210 separate tests, 74 are of two-year olds, 38 of three-year olds, 35 of four-year olds, and 63 of full aged cows. According to this system, each cow will have as many different numbers as she has different tests; for example, numbers 37, 88 and 146 all refer to Clothilde Artis Topsy but to tests conducted at different times in her life. All those heifers which calved between the ages of two years ten and one-half months and three years are considered as three-year olds; for it is presumed that at such age they must have had their second calves, and should not, therefore, be classed as two-year olds. In similar manner and for the same reason the heifers that calved between the ages of three years ten and one-half months and four years are considered as four-year olds.

TABLE I.—PRODUCT OF MILK AND FAT.

Number of test.	Name and herd book number of cow.	Owner.	Age at time of calving. Yr. Mo. Da.	Date of beginning test.	Days from calving	Total pounds of milk.	Average per cent fat.	Total pounds of fat.
1	Agnes DeKol's Ellen, 30228	H. Stevens & Sons	2– 0–17	May 30, '94	81	247.125	3.36	8.304
2	Inka Pietertje Mechthilde, 30668	" "	2– 0–27	" "	36	282.250	3.08	8.696
3	Pietertje Kekke, 28352	" "	2– 6– 1	" "	43	295.875	3.00	8.894
4	DeKol 2d's Pauline, 30712	" "	2– 0– 4	" "	63	245.000	3.72	9.116
5	Netherland Dot, 33359	Smith's & Powell Co.	1–11–27	Aug. 28, '94	7	220.688	2.29	5.263
6	Netherland Clothilde Countess, 27965	" "	2– 8–21	" "	32	256.623	3.00	7.688
7	Idene Clothilde, 30277	" "	2– 6–24	" "	28	261.438	2.76	7.217
8	Sadie Vale Concordia, 32259	T. G. Yeomans & Sons	1–11–25	Nov. 20, '94	28	317.625	3.50	11.116
9	America 2d's Pauline Paul, 32260	" "	1–11–26	" "	24	247.000	2.80	6.906
10	America 2d's Pauline Paul. 32260	" "	1–11–26	Dec. 15, '94	49	236.438	2.87	6.780
11	Sadie Vale Concordia, 32259	" "	1–11–25	" "	53	295.250	3.30	9.756
12	Pietertje Hengerveld 2d, 37054	H. Stevens & Sons	1–11– 5	April 1, '95	26	301.000	3.12	9.395
13	Pietertje Witkop's Mechthilde, 34242	" "	2– 7– 0	June 1, '95	34	289.875	2.90	8.447
14	May DeKol, 36233	" "	1– 9– 7	" "	40	281.625	2.95	8.289
15	Lunde Beauty, 34745	Don J. Wood	1–11–17	June 10, '95	42	280.875	3.35	9.473
16	Clothilde Artis Lass, 34743	" "	1–11–28	" "	61	278.875	3.25	9.062
17	Clothilde Artis Bright, 34742	" "	2– 0–11	" "	51	315.500	3.20	10.026
18	Clothilde Artis Belle, 34740	" "	2– 0–29	June 9, '95	61	273.750	3.40	9.372
19	Rag Apple's Clothilde Artis, 34741	" "	2– 1– 1	June 10, '95	58	291.125	3.45	10.024
20	Pauline Paul Grant, 35053	T. G. Yeomans & Sons	2– 1– 4	Dec. 4, '95	68	354.188	2.96	10.487
21	Sadie Pauline Paul, 35054	" "	2– 0–17	" "	48	289.375	3.24	9.386
22	Princess of Wayne 7th's Pauline, 35055	" "	2– 1–11	Feb. 19, '96	22	242.500	3.75	9.082
23	Princess Aggie's Paul'e DeKol, 35056	" "	2– 0–29	" "	21	243.125	3.24	7.879
24	Aaggie 3's Wayne DeKol, 37098	" "	1–11–13	" "	25	325.500	3.15	10.209
25	Prairie Flower's Pauline Paul 2d, 37168	" "	1–10– 8	April 23, '96	20	321.500	3.17	10.184
26	Mutual Friend's Pauline DeKol, 37171	" "	2– 1–22	" "	51	239.625	3.56	8.538
27	Pauline Paul America 2d, 36909	" "	2–1 –13	" "	57	263.250	3.37	8.860
28	Inka Bess, 40183	H. Stevens & Sons	2– 0–29	May 26, '96	24	298.250	2.82	8.413

Number of test.	Name and herd book number of cow.	Owner.	Age at time of calving Yr. Mo. Da.	Date of beginning test.	Days from calving	Total pounds of milk.	Average per cent fat.	Total pounds of fat.
29	Inka 8th, 37059	H. Stevens & Sons	1–11– 7	May 26, '96	47	242.500	3.15	7.649
30	Inka DeKol, 37062	" " " "	1–11–18	" "	11	306 500	3.24	9.927
31	Pietertje Hengerveld's Lady DeKol, 37060	" " " "	2– 1–11	" "	16	300.375	4.22	12.675
32	Snowball Clothilde, 37527	Don J. Wood	1–11–23	June 1, '96	97	299.313	2.66	7.970
33	Clothilde Jannek Artis, 37526	" " "	1–11–10	" "	74	262.188	3.13	8.219
34	Sweet Bough's Clothilde Artis, 37525	" " "	2– 0–10	" "	78	261.125	2.93	7.656
35	Clothilde Artis Beauty, 37521	" " "	2– 0– 5	" "	84	237.875	3.28	7.814
36	Clothilde Artis June, 37529	" " "	1–10–27	" "	15	243.438	3.24	7.877
37	Clothilde Artis Topsy, 37522	" " "	1–11–24	" "	86	298.250	3.01	8.970
38	America 2d's Pauline DeKol, 37096.	T. G. Yeomans & Sons.	2– 1–29	Dec. 27, '96	21	334.375	2.79	9.339
39	America 2d's Pauline DeKol, 37096*.	" " " " "	2– 1–29	Mar. 21, '97	105	305.188	3.32	10.043
40	Paul DeKol's Mutual Friend, 37172.	" " " " "	2– 0–15	" "	72	242.125	3.50	8.500
41	Paul DeKol 2d's Mutual Friend, 37173	" " " " "	2– 1–23	" "	85	241.188	3.32	8.038
42	Hartog Netherland 2d, 39032	A. F. Cole	2– 2–16	Apr. 18, '97	85	290.625	2.96	8.692
43	Patty Waldorf, 39031	" " "	2– 1–22	Apr. 23, '97	90	244.000	3.12	7.616
44	Aaggie Constance's Netherland 4th, 37256	H. Stevens & Sons	2– 5–10	May 4, '97	23	290.375	3.14	9.111
45	Nether'd Wayne's Pauline Paul, 37095	T. G. Yeomans & Sons.	2– 3–12	May 14, '97	40	315.875	2.69	8.508
46	Clothilde Artis Aaggie Belle, 39862	Don J. Wood	2– 1– 4	May 21, '97	27	269.000	3.46	9.313
47	Clothilde Artis Aaggie Bright, 39864.	" " "	2– 0–23	" "	34	256.313	3.47	8.896
48	Clothilde Artis Aaggie Lass, 39865	" " "	2– 0–21	" "	26	258.188	3.21	8.298
49	Clothilde Artis Constance, 39866	" " "	2– 0– 3	" "	46	275.875	3.05	8.424
50	Clothilde Lunde Artis, 39867	" " "	2– 0– 7	" "	15	281.750	3.34	9.404
51	Hetje 6th's Pietertje, 38945	A. F. Cole	2– 2–10	May 26, '97	6	251.750	3.48	8.783
52	Waldorf Maid, 38938	" " "	2– 0– 3	" "	18	315.750	2.37	7.495
53	Pietertje Tweede, 38949	" " "	1–11–27	" "	35	341.375	2.92	9.980
54	Lily Netherland, 39453	A. W. Brown	2– 0– 7	May 28, '97	112	316.125	2.91	9.185
55	Aaggie Grace Clothilde, 39452	" " "	2– 0– 9	" "	107	280.438	3.17	8.890
56	Mutual Friend 3d's Pauline, 40213	T. G. Yeomans & Sons.	1–11–23	Nov. 30, '97	20	210.625	3.65	7.698
57	Sadie Pauline Paul 2d, 40211	" " " " "	1–11–24	" "	49	156.500	3.39	5.301
58	Plum DeKol, 41677	H. Stevens & Sons	1–11–21	Apr. 2, '98	55	223.500	2.88	6.440
59	Nannette 3ds Pledge 3d, 41407	" " " "	2– 1– 8	Apr. 7, '98	30	312.188	3.76	11.747

60	Aaggie 3d's Wayne's Pauline, 41393.	T. G. Yeomans & Sons	1–11–13	Apr. 18, '98	30	325.625	2.87	9.354
61	Concordia 2d's Pauline, 40212......	" " " " "	2– 3– 3	" "	84	238.250	2.79	6.635
62	Lotty Moselle's PietertjeMechthilde,	A. F. Cole............	2– 2–24	May 20, '98	41	362 500	2.69	9.764
63	Midland Gem, 41611.........[41805	" " "	1–11–19	" "	45	295.563	2.68	7.916
64	Mechthilde of Midland, 41806......	" " "	2– 1–29	" "	46	266.438	2.79	7.456
65	Pietertje Mechthilde of Midland,..	" " "	2– 2– 1	" "	30	282 500	2.74	7.732
66	Hetje 6th's Mechthilde, 41809.[41807	" " "	2– 1– 7	" "	38	292.625	3.07	9.001
67	Shadeland DeKol, 41386..........	W. A. Matteson.......	2– 0–12	May 22, '98	22	315.313	2.86	9.040
68	Inka Hartog 2d, 40507......	W. H. Dewing........	2– 0–28	" "	21	294.938	2.99	8.830
69	DeKol Lady, 41214......	H. Stevens & Sons....	1–11– 2	May 26, '98	23	312.375	3.00	9.384
70	DeKol Manor Beets, 41216.........	" " "	2– 1–15	" "	31	307.000	3.16	9.695
71	Tehee Clothilde, 41383.	A. W. Brown....... .	2– 1–20	June 6, '98	40	283.438	2.86	8.107
72	Aaggie Pietertje Clothilde, 41384...	" " "	2– 0–17	" "	50	267.188	3.13	8.363
73	Clothilde Grace, 41385............	" " "	2– 3– 6	" "	50	316.188	2.95	9.339
74	Segis Clothilde Pietertje, 44589....	" " "	1–10–25	" "	47	265.875	2.87	7.629
75	Netherland Pietertje Princess, 23963	H. Stevens & Sons....	3– 3–16	May 30, '94	5	297.125	4.24	12.593
76	Mutual Friend 3d, 28389..........	T. G. Yeomans & Sons.	3– 2–24	Nov. 20, '94	17	409.188	4.27	17.472
77	Mutual Friend 3d, 28389..........	" " " "	3– 2–24	Dec. 15 '94	42	355.438	3.59	12.738
78	Inka Pietertje Mechthilde, 30668...	H. Stevens & Sons....	2–11–23	Mar. 31, '95	11	349.125	3.25	11.348
79	Pauline Paul Georgie, 28394........	T. G. Yeomans & Sons.	3– 4–20	May 27, '95	15	344.875	3.30	11.406
80	DeKol 2d's Pauline, 30712..........	H. Stevens & Sons....	3– 1–26	June 1, '95	12	338.250	3.45	11.676
81	Hetty W's Artis Clothilde, 31543 ..	Don J. Wood.........	3– 0– 1	June 9, '95	65	311.500	3.40	10.535
82	Sadie Vale Concordia, 32259........	T. G. Yeomans & Sons.	3– 3–29	Apr. 23, '96	56	414.500	3.50	14.485
83	Aaggie Lily 3ds' Netherland, 34799.	A. W. Brown.	3– 2–24	May 31, 96	50	403.500	3.08	12.411
84	Black Maid Inka, 35162......[35055	A. F. Cole...... ...	2–11–16	June 9, '96	78	338.875	2.60	8.813
85	Princess of Wayne 7th's Pauline,	T. G. Yeomans & Sons	3– 4– 8	May 13, '97	18	327.000	3.61	11.824
86	Pauline Paul Grant, 35053.........	" " " "	3– 7– 4	" "	47	417.500	2.90	12.116
87	Princess Aaggie's Pauline DeKol,	" " " "	3– 2–22	" "	51	343.000	3.02	10.378
88	Clothilde Artis Topsy, 37522..[35056	Don J. Wood....... .	3– 1– 8	May 21, '97	30	441.250	3.21	14.176
89	Clothilde Artis Raphaella, 37523 ...	" " "	3– 0– 3	" "	58	361.313	2.90	10.462
90	Clothilde Artis Pet, 37524.........	" " "	3– 0–18	" "	48	312.063	3.08	9.622
91	Aaggie Lily 3d's Pietertje, 37031...	A. W. Brown.........	3– 5– 1	May 28, '97	12	406.188	2.94	11.947
92	Prairie Flower's Pauline Paul 2d, 37168	T. G. Yeomans & Sons.	3– 4–21	Nov. 30, '97	45	310.625	2.85	8.846
93	Mutual Friend's Pauline DeKol, 37171	" " " "	3– 8–12	" "	68	344.125	3.43	11.816
94	Pauline Paul America 2d, 36909....	" " " "	3– 8–24	" "	55	345.500	3.18	11.094

*Economic food test.

Number of test.	Name and herd book number of cow.	Owner.	Age at time of calving. Yr. Mo. Da.	Date of beginning test.	Days from calving	Total pounds of milk.	Average per cent fat.	Total pounds of fat.
95	Nannette 3d's, Pledge 2d, 39518	H. Stevens & Sons	2–10–18	Apr. 2, '98	78	228.625	3.35	7.665
96	Patty's Pet 3d, 38946	A. F. Cole	2–10–16	Apr. 5, '98	31	316.375	2.56	8.091
97	Minnie Hijlaard, 39030	" "	2–10–19	" "	30	318.250	2.84	9.133
98	Patty Waldorf, 39031	" "	3– 3–18	" "	17	364.188	2.97	10.810
99	Zady Bergsma, 37409	H. Stevens & Sons	3– 2– 8	Apr. 7, '98	25	358.438	3.62	12.978
100	Paul De Kol's Mutual Friend, 37172	T. G. Yeomans & Sons	3– 3–29	Apr. 18, '98	27	375.938	3.18	11.955
101	America 2d's Pauline De Kol, 37096	" " "	3– 5–15	" "	27	520.188	3.06	15.903
102	Mutual Friend 2d's Pauline, 41396	" " "	3– 0–13	" "	74	302.813	3.22	9 768
103	Hetje 6th's Pieterje, 38945	A. F. Cole	3– 0–29	May 20, '98	41	384.313	2.89	11.123
104	Clothilde Artis Belle 2d 39861	Don J. Wood	3– 1– 0	May 30, '98	21	349.375	3.12	10.948
105	Clothilde Artis Aaggie Bright, 39864	" "	3– 1–22	" "	14	325.313	3.96	12.875
106	Clothilde Artis Aaggie Lass, 39865	" "	3– 1– 1	" "	25	339.313	3.19	10.824
107	Clothilde Artis Constance, 39866	" "	3– 0–20	" "	38	367.188	3.11	11.423
108	Clothilde Lunde Artis, 39867	" "	2–10–28	" "	64	371.625	3.45	12.821
109	Aaggie Grace Clothilde, 39452	A. W. Brown	3– 3–16	June 6, '98	20	462.375	3.20	14 796
110	Segis Aaggie Grace, 39454	" "	3– 0– 6	" "	27	346.938	3.44	11.811
111	Edith Grace, 39455	" "	2–10–26	" "	38	315.438	2.69	8.512
112	Leah Veeman 4th, 40264	W. A. Matteson	3– 1–24	June 25, '98	23	433.250	2.75	11.908
113	Medora Alice, 22921	H. Stevens & Sons	3–11– 3	May 30, '94	83	299.500	3.27	9.780
114	Pietertje Hengerveld, 24137	" " "	4– 0– 1	" "	62	427.875	3.06	13 124
115	Helena Burke	" " "	4– 3–10	" "	57	418.000	3.21	13.416
116	Inka 4th's Pietertje Rose, 23481	" " "	4– 0–20	" "	36	449.500	2.77	12.449
117	Clothilde 3d's Clothilde, 17955	Smiths & Powell Co.	4– 8–12	Aug. 28, '94	50	231.063	3.03	7.100
118	Netherland Pietertje Hartog, 23962	H. Stevens & Sons	4– 1–14	Mar. 29, '95	12	339.875	3.23	10.972
119	Magadora, 29237	" " "	4– 1– 6	June 1, '95	31	353.625	3.00	10.696
120	Netherland Pietertje Princess, 23963	" " "	4– 2–10	" "	43	434.625	2.95	12.884
121	Mutual Friend 3d, 28389	T. G. Yeomans & Sons	4– 3– 8	Dec. 2, '95	15	427.938	4.27	18.265
122	Segis Aaggie 2d's Pietertje, 32620	A. W. Brown	4– 2– 3	May 31, '96	6	436.875	2.91	12.713
123	Vrouwkje of Hijlaard 8th, 30846	A. F. Cole	3–11–22	June 9, '96	95	403.625	3.14	12.688
124	Rouble 5th's Pietertje, 35079	" "	3–11–29	" "	54	460.000	3.12	14.357
125	Debora's Inka, 30844	" "	4– 5– 0	" "	61	521.250	2.91	15.188

126	Patty's Pietertje Netherland, 30845.	A. F. Cole..........	4– 1–18	June 9, '96	47	418.250	3.09	12.936
127	Inka's Pietertje Netherland Beets...	" "	4 10–14	" "	104	441.375	2.85	12.568
128	Pauline Paul Georgie, 28394...[28453	T. G. Yeomans & Sons	4– 4–15	June 13, '96	37	437.625	3.16	13.808
129	Princess of Wayne 7th, 28690.......	" " "	4– 3–20	" "	40	459.625	2.93	13.450
130	Korndyke Queen, 40580..........	Albert Webb.........	4– 1– 9	June 30, '96	29	518.250	3.19	16.558
131	Creamella 2d's Topsy Ann, 35164....	A. F. Cole..........	3–10 28	Apr. 17, '97	30	412.125	2.59	10.671
132	Hartog Pietertje Netherland, 30849.	" "	4–10–13	Apr. 22, '97	62	415.688	3.86	16.258
133	Clothilde Artis Belle, 34740.........	H. Stevens & Sons ...	4– 1–10	May 4, '97	14	466.750	3.05	14.272
134	Sadie Vale Concordia, 32259.......	T. G. Yeomans & Sons	4– 6– 3	May 14, '97	13	494.250	3.66	18.103
135	Hartog Pietertje Netherland, 30849*	A. F. Cole	4–10–13	May 26, '97	96	403.750	3.44	13.819
136	Winana's Pietertje Netherland, 35084	A. W. Brown........	3–11–29	May 28, '97	28	420.375	2.89	12.153
137	Catrina 4th's Pietertje Netherland,	" "	4– 1–23	" "	18	446.563	3.24	14.457
138	Maplecroft Maid, 35907......[35085	W. A. Matteson.......	4– 2–20	Mar. 11, '98	29	398.500	3.01	12.015
139	Netherland Aaggie Madge, 34960 ..	" "	4– 1–16	Mar. 16, '98	10	355.250	3.02	10.734
140	Belle of Schillaard 3d's Aaggie, 36825	" "	3–11–19	" "	10	302.813	3.52	10.648
141	Prisca, 37278	A. F. Cole	3–10–27	Apr. 5, '98	13	316.125	2.73	8.640
142	Princess Aaggie's Pauline De Kol,..	T. G. Yeomans & Sons	4– 2–24	Apr. 18, '98	24	478.375	3.02	14.461
143	Maplecroft Gem, 35909.......[35056	W. A. Matteson	4– 6– 5	Apr. 22, '98	12	464.750	3.30	15.357
144	Sijtje Twisk Pietertje, 38233	A. F. Cole...........	4–10– 0	May 19, '98	19	377.188	3.19	12.041
145	Inka 8th, 37059..................	H. Stevens & Sons....	4– 0– 3	May 26, '98	21	383.500	3.40	13.069
146	Clothilde Artis Topsy, 37522*........	Don J. Wood.........	4– 1–10	May 30, '98	37	415.750	3.29	13.724
147	Segis Inka, 36617.................	A. W. Brown.........	4– 6–12	June 6, '98	40	476.625	3.11	14.803
148	Netherland Sada, 13381............	H. Stevens & Sons....	5– 8–11	May 30, '94	128	358.875	3.26	11.688
149	Bibiana's Pet, 6778...............	" " "	7– 0–20	" "	69	385.125	3.15	12.137
150	Aaggie B, 13687..................	" " "	5–10– 2	" "	74	409.500	2.91	11.918
151	Netherland Hengerveld, 13106	" " "	5–10– 3	" "	65	410.250	3.32	13.627
152	Inka Hartog, 7969................	" " "	7– 1–16	" "	3	383.125	2.83	10.960
153	Jessie Beets, 8123................	" " "	6– 8–20	" "	65	416.250	3.46	14.433
154	7th Durkje Veeman's Ruby, 13297..	" " "	6– 1– 2	" "	68	368.125	3.06	11.257
155	Aegis 10th, 4941,.................	Smiths & Powell Co...	6– 9–18	Aug. 28, '94	343	228.938	3.83	8.761
156	Clothilde 6th, 1581...............	" " "	8–11– 9	" "	33	320.625	3.26	10.450
157	Idene Rooker, 9995, H. H. B........	" " "	10– 5–10	" "	15	394.625	2.56	10.003
158	Executrix Netherland, 4942........	" " "	7– 7–10	" "	46	319.688	3.06	9.785
159	Netherland Wayne, 13752..........	T. G. Yeomans & Sons	5–10–16	Nov. 20, '94	59	436.000	2.93	12.767
160	Mutual Friend 2d, 10513...........	" " "	7– 0–17	Dec. 15, '94	22	585.125	3.52	20.608

* Economic food test.

Number of test.	Name and herd book number of cow.	Owner.	Age at time of calving. Yr. Mo. Da.	Date of beginning test.	Days from calving	Total pounds of milk.	Average per cent fat.	Total pounds of fat.
161	Plum 4th, 17274	H. Stevens & Sons	6– 0– 5	Mar. 31, '95	20	419.000	3.70	15.519
162	Helena Burke, 22916	" "	5– 3– 0	Apr. 1, '95	9	518.250	2.91	15.089
163	Aaggie 3d's Wayne, 10516	T. G. Yeomans & Sons	7– 4– 5	May 27 '95	21	487.063	3.22	15.705
164	Inka Hartog, 7969	H. Stevens & Sons	8– 0–16	June 1, '95	35	494.125	2.95	14.573
165	Plum 4th, 17274	" "	6– 0– 5	" "	82	465.250	3.20	14.837
166	Netherland Wayne, 13752	T. G. Yeomans & Sons	6–11– 4	Dec. 2, '95	53	446.438	2.79	12.470
167	Concordia 2d, 10511	" "	8– 0– 4	" "	42	469.938	3.23	15.190
168	Mutual Friend 2d's Wayne, 18456	" "	5–10– 9	Dec. 3, '95	58	524.563	3.41	17.888
169	Concordia 2d's America, 22979	" "	5– 8–18	" "	60	392.563	2.95	11.568
170	Star's Netherland, 13802	" "	7–10–19	Feb. 19, '96	9	468.188	3.56	16.675
171	Aaggie 3d's Wayne, 10516	" "	8– 3– 5	Apr. 23, '96	17	497.063	3.34	16.582
172	Netherland VanFrieslandBeets, 23672	H. Stevens & Sons	5– 5–26	May 26, '96	140	422.375	3.29	13.880
173	Magadora, 29237	" "	5– 1–20	" "	11	444.500	2.84	12.605
174	Netherland Hengerveld, 13106	" "	7–11– 7	" "	23	544.875	3.92	21.333
175	Minnie Maria, 8229	A. W. Brown	8– 7–29	May 31, '96	14	467.563	2.52	11.767
176	Segis Aaggie 2d, 24052	" "	6– 2–12	" "	9	449.125	2.83	12.715
177	Aaggie Grace 2d's Pietertje, 26731	" "	5– 2 –0	" "	61	624.938	2.87	17.906
178	Sweet Bough, 7328	Don J. Wood	9– 2–13	June 1, '96	23	428.875	3.12	13.398
179	Patty's Pet, 5405	A. F. Cole	9–11–13	June 9, '96	89	380.125	3.30	12.562
180	Maid of Eaton Inka, 28448	" "	5– 1–10	" "	54	458.250	2.66	11.371
181	Sadie Vale 2d, 18449	T. G. Yeomans & Sons	7– 2–25	Dec. 27, '96	74	322.813	3.13	10.099
182	Mutual Friend 2d, 10513	" "	9– 1– 3	" "	18	589.250	3.44	20.242
183	Aaggie 3d's Wayne, 10516*	" "	9 2–12	Mar. 21, '97	8	410.000	3.64	14.773
184	Mutual Friend 3d, 28389	" "	5– 6 15	" "	25	431.938	3.83	16.327
185	Patty's Pet, 5405	A. F. Cole	11– 0– 2	Apr. 22, '97	22	453.500	3.57	16.203
186	Janie Hijlaard's Inka, 30852	" "	5– 0–26	Apr. 23, '97	30	446.063	3.43	15.320
187	Helena Burke, 22916	H. Stevens & Sons	7– 3–10	May 4, '97	31	654.125	3.11	20.364
188	Pauline Paul Georgie, 28394	T. G. Yeomans & Sons	5– 3 20	May 12, '97	30	376.125	3.40	12.819
189	Princess of Wayne 7th, 28690	" "	5– 2–29	May 13, '97	30	463.625	3.16	14.680
190	Mutual Friend 3d, 28389*	" "	5– 6–15	May 14, '97	79	363.875	3.34	12.184

*Economic food test.

191	Aaggie Grace's Boy's Topsy, 22946	Don J. Wood	7- 0-17	May 21, '97	39	448.375	2.99	13.410
192	Patty's Pet, 5405*	A. F. Cole	11- 0- 2	May 26, '97	56	460.875	3.35	15.459
193	Janie Hijlaard's Inka, 30852	" "	5- 0 26	" "	63	451.125	3.00	13.536
194	Debora's Inka, 30844	" "	5- 5-23	" "	24	509.000	3.08	15.667
195	Vrouwkje of Hijlaard 7th, 28449	" "	6- 1- 4	" "	38	441.625	3.04	13.427
196	Creamella 2d, 10725	" "	9-10-15	" "	39	472.250	3.12	14.757
197	Aaggie Grace 2d's Pietertje, 26731	A. W. Brown	6- 2-23	May 28, '97	34	651.750	2.89	18.803
198	Sadie Vale 2d, 18449	T. G. Yeomans & Sons	8- 3-14	Nov. 30, '97	27	340.250	3.40	11.656
199	Inka Pietertje Mechthilde, 30668	H. Stevens & Sons	5-10-29	Apr. 2, '98	35	409.938	3.08	12.614
200	Shadeland Angie, 21700	W. A. Matteson	8- 2-22	Apr. 17, '98	20	423.875	2.91	12.347
201	Sadie Vale Concordia, 32259*	T. G. Yeomans & Sons	5- 5- 3	Apr. 18, '98	18	542.313	3.09	16.772
202	Mutual Friend 3d, 28389*	" "	6- 6-26	" "	44	427.438	3.44	14.724
203	Princess of Wayne 7th, 28690	" "	6- 1-27	" "	38	491.438	3.17	15.600
204	Shadeland Ruby 5th, 29558	W. A. Matteson	6-11- 7	Apr. 19, '98	11	443.375	2.81	12.501
205	Vrouwkje of Hijlaard 7th, 28449	A. F. Cole	7- 0-26	May 19, '98	39	492.250	3.00	14.791
206	Jannek Bright 2d, 22943	Don J. Wood	8- 0-10	May 30, '98	69	448.875	3.28	14.730
207	Aaggie Grace's Boy's Topsy, 22946	" "	8- 0-13	" "	54	458.250	3.01	13.800
208	Jannek Beauty'sInka Pietertje, 28681	" "	7- 0- 1	" "	59	392.563	3.22	12.563
209	Segis Aaggie 2d's Pietertje, 32620	A. W. Brown	6- 0-25	June 6, '98	50	452.125	2.97	13.437
210	Shadeland Amber, 29330	W. A. Matteson	7- 1-18	June 25, '98	65	420.875	3.22	13.073

*Economic food test.

SUMMARY OF TABLE I.

A. Average Production of Milk and Fat.

Age.	Number of cows.	Pounds of milk.	Per cent fat.	Pounds of fat.
Average for Cows Tested While at Pasture.				
Two-year-olds	47	282.531	3.07	8.680
Three-year-olds.	19	363.431	3.18	11.541
Four-year-olds..........	23	418.905	3.09	12.947
Full aged cows..........	35	435.573	3.08	13.412
Average	124	363.419	3.09	11.245
Average for Cows Tested While not at Pasture.				
Two-year-olds	27	274.326	3.18	8.726
Three-year-olds.........	19	355.036	3.26	11.570
Four-year-olds.	12	406.036	3.29	13.366
Full aged cows	28	458.362	3.27	14.975
Average.....	86	370.454	3.25	12.036
Average for All the Cows Taken Together.				
Two-year-olds	74	279.537	3 11	8 697
Three-year-olds	38	359.234	3.22	11.555
Four-year-olds..	35	414.493	3.16	13.091
Full aged cows	63	445.701	3.16	14.106
Average of all	210	366.300	3.16	11.569

B. Largest and Smallest Records of Cows of Different Ages.

(The largest and smallest yields of milk and fat and the highest and lowest per cent of fat are indicated by heavy type.)

Age.	Largest records.				Smallest records.			
	No. in table I.	Pounds of milk.	Av'ge per cent fat.	Pounds of fat.	No. in table I.	Pounds of milk.	Av'age per cent fat.	Pounds of fat.
Two-year-olds.....	30	300.375	**4.22**	**12.675**	5	220.688	**2.29**	**5.263**
	62	**362.500**	2.69	9.764	57	**156.500**	3.39	5.301
Three-year-olds.....	76	409.188	**4.27**	**17.472**	95	**228.625**	3.35	**7.665**
	101	**520.188**	3.06	15.903	96	316.375	**2.56**	8.091
Four-year-olds.....	121	427.938	**4.27**	**18.265**	117	**231.063**	3.03	**7.100**
	125	**521.250**	2.91	15.188	141	316.125	**2.73**	8.640
Full aged cows....	174	544.875	**3.92**	**21.333**	155	**228.938**	3.83	**8.761**
	187	**654.125**	3.11	20.364	175	467.563	**2.52**	11.767

A close study of Table I and its summary reveals a large variation in production between animals of the same age. Among two-year olds the largest milk record for seven days is that of No. 62 (Lotty Moselle's Pietertje Mechthilde) with 362.5 pounds, containing 9.764 pounds of fat and an average fat content of 2.69 per cent. The lowest milk record is that of No. 57 with 156.5 pounds, containing 5.301 pounds of fat and an average fat content of 3.39 per cent. The largest production of fat is that of No. 31 (Pietertje Hengerveld's Lady De Kol) with 12.675 pounds from 300.375 pounds of milk containing an average of 4.22 per cent fat, which is the highest average found among the two-year olds The smallest production of fat is that of No. 5 with 5.263 pounds from 220.688 pounds of milk containing an average of 2.29 per cent fat, which is the lowest average found among two-year olds.

The average production for all two-year olds is 279.537 pounds of milk, 3.11 per cent fat and 8.697 pounds of fat.

Of the three-year olds No. 101 (America 2d's Pauline DeKol) leads in the production of milk with 520.188 pounds, containing 15.903 pounds of fat and an average of 3.06 per cent fat. The largest production of fat is by No. 76 (Mutual Friend 3d) with 17.472 pounds from 409.188 pounds of milk containing an average of 4.27 per cent fat which is the highest average found among four-year olds. No. 95 produced the smallest amount of both milk and fat, her record at this time being 228,625 pounds of milk and 7.665 pounds of fat. The lowest per cent of fat was given by No. 96 whose average was 2.56 ; her total milk and fat yield was 316.375 and 8.091 pounds respectively.

The average production for all three-year olds was 359.234 pounds of milk, 3.22 per cent of fat and 11.555 pounds of fat.

Among the four-year olds the one producing the most milk in seven days is No. 125 (Debora's Inka) with 521.25 pounds containing 15.188 pounds of fat and 2.91 per cent fat. The same heifer (Mutual Friend 3d) that led the three-year olds as No. 76 in total yield of fat and in average per cent fat, also leads, as No. 121, the four-year olds in the same respect. Her yield of fat was 18.265 pounds from 427.938 pounds of milk containing an average of 4.27 per cent fat, or exactly the same percentage her milk

contained as a three-year old. No. 117 produced the smallest amount of both milk and fat, the former being 231.063 pounds and the latter 7.1 pounds. The lowest per cent of fat was given by No. 141 whose average was 2.73. Her total milk and fat yield was 316.125 and 8.64 pounds respectively.

The average production for four-year olds is 414.493 pounds of milk, 3.16 per cent fat and 13.091 pounds of fat.

Among the full aged cows No. 187 (Helena Burke) leads in milk production with 654.125 pounds containing 20.364 pounds of fat and an average of 3.11 per cent fat. The largest production of fat is by No. 174 (Netherland Hengerveld) with 21.333 pounds from 544.875 pounds of milk containing an average of 3.92 per cent fat which is the highest average found among full aged cows. The lowest record for milk and fat is by No. 155 with 228.938 pounds of milk and 8.761 pounds of fat and an average of 3.83 per cent fat. The lowest per cent of fat was given by No. 175 whose average was 2.52. Her yield of milk was 467.563 pounds and of fat 11.767 pounds.

The average production of full aged cows is 445.701 pounds of milk, 3.16 per cent fat and 14.106 pounds of fat.

It is interesting to note that in all ages but two-year olds the smallest production of milk and of fat fall to the same cow and at the same test,—No. 95 in three-year olds, No. 117 in four-year olds and No. 155 in full aged cows. Also, that in every age, the highest per cent of fat is accompanied with the highest total yield of fat, but in no case are these two accompanied by the largest total yield of milk. On the other hand, the lowest per cent of fat is accompanied by the smallest total yield in but one instance, and that among two-year olds.

The gain in production of the older animals over the younger shows a constant decrease as the age increases. The gain of three over two-year olds is 28.5 per cent in milk and 32.7 per cent in fat; of four over three-year olds is 12.6 per cent in milk and 18.2 per cent in fat; and of full aged cows over four year-olds is 7.5 per cent in milk and 7.7 per cent in fat.

COWS AT PASTURE AND NOT AT PASTURE.

Of the 210 separate tests made, 124 were of animals at pasture and which also received more or less grain. The remaining 86 cows were entirely stall fed. A study of the Summary of Table I shows a variation in production between those at pasture and those not at pasture. The number at pasture is considerably larger than the number not at pasture, and for this reason a comparison of averages does not carry so much weight as if there were the same number in each class, but because of the large number in each class we can draw conclusions that are fairly representative. Indeed the number of three-year olds at pasture is the same as those not at pasture and their records bear approximately the same relation to each other as do those of the two and four-year olds.

In production of milk, the average for two, three and four-year olds at pasture is greater than the average for the same ages among those not at pasture. On the other hand, the cows not at pasture have a higher average production of fat than those of corresponding ages at pasture. This is because the milk of the stall fed cows averages about one-tenth of one per cent higher in fat. When we come to the full aged cows the order is different, for here the stall fed cows average higher than those at pasture in production of milk as well as in total fat and per cent of fat. The difference in average production is 22.789 pounds of milk, 1.383 pounds of fat and .19 per cent fat. Taking the average of all the records we find the animals not at pasture exceed those at pasture in average weekly production by 7.035 pounds of milk, .791 pounds of fat and .16 per cent fat.

From these averages it would seem that there is a slight advantage in production to be obtained by judicious stall feeding over pasture feeding. Whether this results from feed alone or from weather and temperature effects is not determined. Some feeders prefer stall feed and cool, brisk winter weather for the best results. Others claim they can obtain better records in summer with rich pasture and bright, hot weather. Instances may be found which tend to show that both may be right. The matter may resolve itself into the question as to during which season the effects of temperature and weather upon the comfort of the

cow can be best controlled. When cattle are kept in the stable, bad weather is expected and provisions are made to protect the animals from the elements, to keep them dry and warm, and to make their environment as uniform and comfortable as possible. Under such conditions the cow may be expected to do her best. On the other hand, with the cows at pasture no provision is usually made for feed in the stable, other than grain, and they are obliged to stay out-of-doors no matter what the weather. If it be warm and dry the cow is likely to do well, but if it be cool and damp, as is often the case during the early summer months, she cannot be expected to do her best. Extreme changes in temperature or continuous rainy weather with the cold, damp ground to lie on at night are not conditions calculated to be followed by large records. From our recollections of the tests we are led to say that possibly the majority of tests on pasture were made under unfavorable weather conditions. But few notes were taken on this point and thus no definite conclusions can be arrived at.

THE FOOD CONSUMED.

In Table II is given, after the name of the cow, the amount of each kind of grain and coarse fodder and the total pounds of grain and coarse fodder she consumed daily. Also the total amount of dry matter consumed during the seven days, the pounds of dry matter consumed for each one hundred pounds of milk and each pound of fat produced, and the nutritive ratio of the food. In the calculations of dry matter and nutritive ratio pasture is not included.

The data for compiling this table was obtained, in each case, from the statement of the owner or feeder of the animal as to what food she was receiving daily. It was usually based upon the actual weight of food consumed for some one day of the test. No attempt was made, except in the case of "Economic Food Tests," to secure official information as to the exact amount of food consumed by each animal, but we have every reason to believe that the statements made by the owners or feeders are substantially correct. We have seen no instance where there appeared to be any attempt to give the cow more food than the statement called for. We believe, therefore, that this table gives

as accurate information concerning the food of each animal as could be obtained without actually weighing out daily each kind of grain and coarse fodder to be given her. For the cows entered in the "Economic Food Tests," to be described later, each day's ration was carefully weighed out by the supervisor of the test, and he was required to make affidavit, the same as for the milk and fat record, that, to the best of his knowledge, the cow received no other food than was named in the statement.

The names of the cows are arranged in the same manner as in Table I with the same numbers and in the same order as to time of test. Thus the reader can readily follow the same animal through the two tables, first to ascertain the amount of milk and butter fat she produced and second the quantity of food she consumed while producing it.

TABLE II.—AMOUNT AND KIND OF FOOD CONSUMED.

Number of test.	Name of cow.	Daily ration.													Dry matter consumed.			
		Grain.							Coarse fodder.									
		Wheat bran.	Corn meal.	Oats, ground.	Cotton-seed meal.	Oil meal.	Miscel-laneous.	Total grain.	Corn silage.	Hay.	Corn-stalks.	Miscel-laneous.	Total coarse fodder.		Total for seven days.	For 100 pounds of milk.	For 1 pound of fat.	Nutritive ratio.
1	Agnes DeKol's Ellen	3	1¾	3		1	o ¼	9				Pasture			56.01			1:4.6
2	Inka Pietertje Mechthilde	3	1¾	3		1	o ¼	9				"			56.01			1:4.6
3	Pieterje Kekke	3	1¾	3		1	o ¼	9				"			56.01			1:4.6
4	DeKol's 2d's Pauline	3	1¾	3		1	o ¼	9				"			56.01			1:4.6
5	Netherland Dot	6¾	4	3			b 3¾	17½				"			109.97			1:4.6
6	Netherland Clothilde Countess	6¾	4	3			b 3¾	17½				"			109.97			1:4.6
7	Idene Clothilde	6¾	4	3			b 3¾	17½				"			109.97			1:4.6
8	Sadie Vale Concordia	12¾	10½	5¾	4	4¼		37¼	25		5	S. 23	53		341.67	107.57	30.73	1:4.4
9	America 2d's Pauline Paul	11	9½	5	3¾	4		33¼	25		5	S. 21	51		312.62	126.56	45.27	1:4.7
10	America 2d's Pauline Paul	0	10	5	4½	4		33½	23		1½	S. 17½	42		288.12	121.85	42.49	1:4.2
11	Sadie Vale Concordia	0	10	5	4½	4		33½	23		1½	S. 17½	42		288.12	97.58	29.53	1:4.2
12	Pietertje Hengerveld 2d	8¾	3⅝	2		5⅝		20	40	10		P. 12	62		260.54	86.56	27.73	1:4.9
13	Pietertje Witkop's Mechthilde	3¼	2½	1½				7¼		2		Pasture			56.77			1:5.5
14	May De Kol	3¼	2½	1½				7¼		2		"			56.77			1:5.5
15	Lunde Beauty	3½	½	1	¾	½	b 1¼	7½				"			47.15			1:3.3
16	Clothilde Artis Lass	3½	½	1	¾	½	b 1¼	7½				"			47.15			1:3.3
17	Clothilde Artis Bright	3½	½	1	¾	½	b 1¼	7½				"			47.15			1:3.3
18	Clothilde Artis Belle	3½	½	1	¾	½	b 1¼	7½				"			47.15			1:3.3
19	Rag Apple's Clothilde Artis	3½	½	1	¾	[illegible]	b 1¼	7½				"			47.15			1:3.3
20	Pauline Paul Grant	7	4¼	4¼	5	5¼		25¾	37		4	S. 25	66		282.87	79.83	26.97	1:4.1
21	Sadie Pauline Paul	7	4¼	4¼	5	5¼		25¾	37		4	S. 25	66		282.87	97.75	30.13	1:4.1
22	Princess of Wayne 7th's Pauline	7	4¼	4¼	5	5¼		25¾	37		4	S. 25	66		282.87	116.64	31.14	1:4.1
23	Princess Aaggie's Pauline DeKol	7	4¼	4¼	5	5¼		25¾	37		4	S. 25	66		282.87	116.35	35.81	1:4.1
24	Aaggie 3d's Wayne DeKol	7	4¼	4¼	5	5¼		25¾	37		4	S. 25	66		282.87	86.90	27.71	1:4.1

25	Prairie Flower's Pauline Paul 2d	10	5	5	5	4		29	30		7½	S. 34	71½	332.68	103.47	32.66	1:4.4
26	Mutual Friend's Pauline DeKol.	10	5	5	5	4		29	30		7½	S. 34	71½	332.68	138.83	38.96	1:4.4
27	Pauline Paul America 2d.......	10	5	5	5	4		29	30		7½	S. 34	71½	332.68	126.39	37.55	1:4.4
28	Inka Bess	5½	1½	1		3½	e1½	13		6		P. 8	Pasture.	128.59			1:4.2
29	Inka 8th	5½	1½	1		3½	e1½	13		6		P. 8	"	128.59			1:4.2
30	Inka DeKol	5½	1½	1		3½	e1½	13		6		P. 8	"	128.59			1:4.2
31	PietertjeHengerveld'sLdyDeKol	5½	1½	1		3½	e1½	13		6		P. 8	"	128.59			1:4.2
32	Snowball Clothilde	2⅖			⅘	⅕	r 5⅗	9				Pasture.		56.02			1:3.7
33	Clothilde Jannek Artis	2⅖			⅘	⅕	r 5⅗	9				"		56.02			1:3.7
34	Sweet Bough's Clothilde Artis..	2⅖			⅘	⅕	r 5⅗	9				"		56.02			1:3.7
35	Clothilde Artis Beauty	2⅖			⅘	⅕	r 5⅗	9				"		56.02			1:3.7
36	Clothilde Artis June	2⅖			⅘	⅕	r 5⅗	9				"		56.02			1:3.7
37	Clothilde Artis Topsy.	2¾			⅞	¼	r6⅜	10¼				"		63.79			1:3.7
38	America 2d's Pauline DeKol ...	7	6½	3¾	3¾	3½		24½	36		6		42	230.65	68.98	24.69	1:4.5
39	America 2d's Pauline DeKol*...	2 3/7	2 6/7	1 5/7	1 1/7	1 1/7		10 1/7	60		3		63	166.02	54.39	16.53	1:6.0
40	Paul DeKol's Mutual Friend....	9	4½	2½	2	2		20	49		5½		54½	226.52	93.55	26.65	1:5.1
41	Paul DeKol 2d's Mutual Friend.	9	6	3¼	2	2	g1¼	23¼	49		5½		54½	248.43	103.00	30.90	1:5.0
42	Hartog Netherland 2d	5½				4	f5½	15	22	15		P. 30	67	260.05	89.48	29.92	1:5.9
43	Patty Waldorf............[4th	5½				4	f5½	15	22	15		P. 30	67	260.05	106.57	34.14	1:5.9
44	Aaggie Constance's Netherland	8½	3	2		1¼	i 2	16¾	35	8		P. 10	53	227 01	78.18	24.92	1:6.3
45	Netherland Wayne'sPaulinePaul	6	3¾	2	2	1¼		15	70	5			75	226.73	71.78	26.65	1:5.8
46	Clothilde Artis Aaggie Belle ...	2	1⅖	1⅖	⅖	⅕	b 4	9				Pasture.		56.30			1:3.7
47	Clothilde Artis Aaggie Bright...	2	1⅖	1⅖	⅖	⅕	b 4	9				"		56.30			1:3.7
48	Clothilde Artis Aaggie Lass	2	1⅖	1⅖	⅖	⅕	b 4	9				"		56.30			1:3.7
49	Clothilde Artis Constance	2	1⅖	1⅖	⅖	⅕	b 4	9				"		56.30			1:3.7
50	Clothilde Lunde Artis..........	2	1⅖	1⅖	⅖	⅕	b 4	9				"		56.30			1:3.7
51	Hetje 6th's Pietertje	3				2¼	f 3	8¼				P. 15	Pasture.	65.48			1:4.8
52	Waldorf Maid..................	3				2¼	f 3	8¼				P. 15	"	65.48			1:4.8
53	Pieterje Tweede	4				3	f 4	11				P. 30	"	106.57			1:5.2
54	Lily Netherland	2¼		2¼			b4½	9					"	56.95			1:3.5
55	Aaggie Grace Clothilde	2¼		2¼			b4½	9					"	56.95			1:3.5
56	Mutual Friend 3d's Pauline.....	8	7	4	4	1	g1	25	40		6		46	221.83	105.32	28.81	1:6.3
57	Sadie Pauline Paul 2d.........	8	7	4	4	1	g1	25	40		6		46	221.83	141.75	41.47	1:6.3
58	Plum DeKol..................	10		2			16	18	30	6		C. 15	51	204.82	91.64	31.80	1:6.0
59	Nannette 3d's Pledge 3d	10		2			16	18	30	6		C. 15	51	204.82	65.61	17.35	1:6.0
60	Aaggie 3d's Wayne's Pauline ...	4	5	3	1	1		14	50	6			56	196.28	60.28	20.98	1:6.0

*Economic food test.

Number of test.	Name of cow.	Daily rations. Grain. Wheat bran.	Corn meal.	Oats ground.	Cotton-seed meal.	Oil meal.	Miscellaneous.	Total grain.	Coarse fodder. Corn silage.	Hay.	Corn stalks.	Miscellaneous.	Total coarse fodder.	Dry matter consumed. Total for seven days.	For 100 pounds of milk	For 1 pou'd of fat.	Nutritive ratio.
61	Concordia 2d's Pauline...[thilde	4	7	4	2	2		19	56	6			62	236.53	99.28	35.64	1:5.5
62	Lotty Moselle's Pieterje Mech-	2 4/7	2 4/7			1 2/7	b 3 6/7	10 2/7				Pasture		64.44			1:3.3
63	Midland Gem..................	1 6/7	1 6/7			1	b 2 5/7	7 3/7				"		46.54			1:3.3
64	Mechthilde of Midland.........	2	2 1/7			1	b 3 1/7	8 2/7				"		51.91			1:3.3
65	Pietertje Mechthilde of Midland.	2¼	2¼			1⅛	b 3⅜	9				"		55.94			1:3.3
66	Hetje 6th's Mechthilde.........	2¼	2¼			1⅛	b 3⅜	9				"		55.94			1:3.3
67	Shadeland DeKol...............	4	1	4	4	3/5	b 4	17 3/5				"		111.16			1:2.3
68	Inka Hartog 2d...............	4	1	4	4	3/5	b 4	17 3/5				"		111.16			1:2.3
69	DeKol Lady..................			1 3/5			l 5 1/5	6 4/5				"		42.04			1:5.4
70	DeKol Manor Beets............			1 3/5			l 5 1/5	6 4/5				"		42.04			1:5.4
71	Tehee Clothilde................	6¾			⅞	⅞	b 6¾	15				"		94.85			1:3.1
72	Aaggie Pietertje Clothilde.....	6¾			⅞	⅞	b 6¾	15				"		94.85			1:3.1
73	Clothilde Grace...............	6¾			⅞	⅞	b 6¾	15				"		94.85			1:3.1
74	Segis Clothilde Pietertje.......	5¼			¾	¾	b 5¼	12				"		75.88			1:3.1
75	Netherland Pietertje Princess.	3	1	3		1	o 1	9				"		53.34			1:4.6
76	Mutual Friend 3d..............	12	10½	6½	4¼	5		38¼	25		5	S. 23	53	347.83	85.00	19.91	1:4.4
77	Mutual Friend 3d..............	10¾	10¾	5¼	4¾	4		35½	22		1½	S. 17½	41	300.65	84.58	23.60	1:4.2
78	Inka Pietertje Mechthilde.....	10¾	4⅜	2½		6⅜		24	40	10		P. 12	62	285.46	81.76	25.15	1:4.6
79	Pauline Paul Georgie..........	7	7	4	8	12		38	36	3		R. 40	79	394.17	114.29	34.56	1:3.3
80	DeKol 2d's Pauline	4½	4	2				10½		2		Pasture		76.86			1:5.6
81	Hetty W's Artis Clothilde......	3½	½	1	¾	½	b 1¼	7½				"		47.15			1:3.3
82	Sadie Vale Concordia.........	14	9	7½	7½	5¼		43¼	30		7½	S. 34	71½	423.33	102.12	29.22	1:3.9
83	Aaggie Lily 3d's Netherland....	9					b 4½	13½				Pasture		84.42			1:3.8
84	Black Maid Inka..........	2	2			2½	a 4	10½				P. 15	Pasture	88.06			1:3.7
85	Princess of Wayne 7th's Pauline.	9	6	4	4	2	g 1	26	77	5			82	305.83	93.52	25.87	1:5.0
86	Pauline Paul Grant...........	9	6	4	4	2	g 1	26	77	5			82	305.83	73.25	25.24	1:5.0

87	Princess Aaggie's Pauline DeKol	9	6	4	4	2	g 1	26	77	5			82	305.83	89.16	29.47	1:5.0
88	Clothilde Artis Topsy	2 2/3	1 1/2	1 1/2	2/3	1/3	b 4 1/3	11				Pasture		68.82			1:3.7
89	Clothilde Artis Raphaella	2 2/3	1 1/2	1 1/2	2/3	1/3	b 4 1/3	11				"		68.82			1:3.7
90	Clothilde Artis Pet	2 2/3	1 1/2	1 1/2	2/3	1/3	b 4 1/3	11				"		68.82			1:3.7
91	Aaggie Lily 3d's Pietertje	2 3/4		2 3/4			b 5 1/2	11				"		69.58			1:3.5
92	Prairie Flower's Pauline Paul 2d.	11	8	6	6	2	g 1	34	60		7		67	338.80	109.07	38.30	1:4.7
93	Mutual Friend's Pauline DeKol.	11	8	6	6	2	g 1	34	60		7		67	338.80	98.16	28.67	1:4.7
94	Pauline Paul America 2d	11	8	6	6	2	g 1	34	60		7		67	338.80	98.06	30.54	1:4.7
95	Nannette 3d's Pledge 2d	10		2			l 6	18	30	6		C. 15	51	204.82	89.58	26.72	1:6.0
96	Patty's Pet 3d	4 1/4	4 1/4			2	a 6 1/2	17	50	20			70	298.62	94.42	36.91	1:4.9
97	Minnie Hijlaard	4 1/4	4 1/4			2	a 6 1/2	17	50	20			70	298 62	93.83	32.69	1:4.9
98	Patty Waldorf	4 1/4	4 1/4			2	a 6 1/2	17	50	20			70	298.62	81.99	27.62	1:4.9
99	Zady Bergsma	10		2			l 6	18	30	6		C. 15	51	204.82	57.14	15.77	1:6.0
100	Paul DeKol's Mutual Friend	7	9	5	2	1		24	56	6			62	267.47	71.72	22.37	1:5.8
101	America 2d's Pauline DeKol	7	10	7	3	2		29	56	6			62	285.04	54.79	17.92	1:5.3
102	Mutual Friend 2d's Pauline	4	7	4	2	2		19	56	6			62	236.53	78.11	24.21	1:5.5
103	Hetje 6th's Pietertje	2 4/7	2 4/7			1 2/7	b 3 6/7	10 2/7				Pasture		64.44			1:3.3
104	Clothilde Artis Belle 2d	2				1	t 7	10				"		62.86			1:2.6
105	Clothilde Artis Aaggie Bright		5/6	2/3	1/3		r 8 1/6	10				"		63.21			1:3.0
106	Clothilde Artis Aaggie Lass		1 2/3	1 1/3	2/3		r 6 1/3	10				"		62.93			1:3.5
107	Clothilde Artis Constance		1 2/3	1 1/3	2/3		r 6 1/4	10				"		62.93			1:3.5
108	Clothilde Lunde Artis		1 2/3	1 1/3	2/3		r 6 1/3	10				"		62.93			1:3.5
109	Aaggie Grace Clothilde	9 1/3			1 1/6	1 1/6	b 9 1/3	21				"		131.79			1:3.1
110	Segis Aaggie Grace	6 3/4			7/8	7/8	b 6 3/4	15				"		94.85			1:3.1
111	Edith Grace	6 3/4			7/8	7/8	b 6 3/4	15				"		94.85			1:3.1
112	Leah Veeman 4th	6					a 6	12				"		74.97			1:2.9
113	Medora Alice	2 1/5	3 1/5	3		1	o 1 1/5	10 3/5				"		66.94			1:5.3
114	Pietertje Hengerveld	2 1/5	3 1/5	3		1	o 1 1/5	10 3/5				"		66.94			1:5.3
115	Helena Burke	2 1/5	3 1/5	3		1	o 1 1/5	10 3/5				"		66.94			1:5.3
116	Inka 4th's Pietertje Rose	1 5/7	2 3/7	2 3/7		6/7	o 6/7	8 2/7				"		51.59			1:5.3
117	Clothilde 3d's Clothilde	9 1/2	6	4 3/4			b 5	25 1/4				"		158.76			1:4.6
118	Netherland Pietertje Hartog	10 3/4	4 3/8	2 1/2		6 3/8		24	40	10		P. 12	62	285.46	83.99	26.01	1:4.6
119	Magadora	4 1/2	4	2				10 1/2		2		Pasture		76.86			1:5.6
120	Netherland Pietertje Princess	4 1/2	4	2				10 1/2		2		"		76.86			1:5.6
121	Mutual Friend 3d	9	5 3/4	5 3/4	8 3/4	5 3/4		35	37		4	S. 25	66	345.73	80.79	18.93	1:3.7
122	Segis Aaggie 2d's Pietertje	9					b 4 1/2	13 1/2				Pasture		84.42			1:3.8

Number of test.	Name of cow.	Daily ration. Grain. Wheat bran.	Corn meal.	Oats ground.	Cotton-seed meal.	Oil meal.	Miscel-laneous.	Total grain.	Coarse fodder. Corn silage.	Hay.	Corn-stalks.	Miscel-laneous.	Total coarse fodder.	Dry matter consumed. Total for seven days.	For 100 pou'ds of milk.	For 1 pou'd of fat.	Nutri-tive ratio.
123	Vrouwkje of Hijlaard 8th........	2	2			2½	a 4	10½				P. 15	Pasture	88.06			1:3.7
124	Rouble 5th's Pietertje..........	2	2			2½	a 4	10½				P. 15	"	88.06			1 3 7
125	Debora's Inka	3½	3½			3½	a 7	17½				P. 15	"	132.02			1:3.4
126	Patty's Pietertje Netherland ..	3½	3½			3½	a 7	17½				P. 15	"	132.02			1:3.4
127	Inka's Pietertje NetherlandBeets	3½	3½			3½	a 7	17½				P. 15	"	132.02			1:3.4
128	Pauline Paul Georgie...........	14	8	4½	4½	4		35	92			Pasture.	92	352.52	80.56	25.55	1:2.3
129	Princess of Wayne 7th..........	14	8	4½	4½	4		35	92			"	92	352.52	76.69	26.21	1:2.3
130	Korndyke Queen	3½	4	9				16½				"		101.55			1:6.1
131	Creamella 2d's Topsy Ann.......	6				4½	f 6	16½	22	15		P. 30	67	269.50	65.39	25.25	1:5.8
132	Hartog Pietertje Netherland...	6				4½	f 6	16½	22	15		P. 30	67	269.50	64.83	16.57	1:5.8
133	Clothilde Artis Belle...	8½	3	2		1¼	i 2	16¾	35	8		P. 10	53	227.01	48.64	15.91	1:6.3
134	Sadie Vale Concordia...........	9	6	4	4	2	g 1	26	77	5			82	305.83	61.88	16.89	1:5.0
135	Hartog Pietertje Netherland*...	2⅞		2¼			f 2⅞	8				P. 25	Pasture	82.18			1:5.4
136	Winana's Pietertje Netherland.	2¾		2¾			b 5½	11					"	69.58			1:3.5
137	Catrina4th'sPietertje Netherland	2¾		2¾			b 5½	11					"	69.58			1:3.5
138	Maplecroft Maid................	10½	3	5½		1½	b 5½	26	25	8			33	247.24	62.04	20.57	1:4.1
139	Netherland Aaggie Madge	10½	3	5½		1½	h 5½	26	25	8			33	247.24	69.59	23.03	1:4.1
140	Belle of Schillaard 3d's Aaggie.	10½	3	5½		1½	h 5½	26	25	8			33	247.24	81.65	23.30	1:4.1
141	Prisca.........................	4¼	4¼			2	a 6½	17	50	20			70	298.62	94.46	34.56	1:4.9
142	Princess Aaggie's Pauline DeKol.	7	9	5	2	1		24	56	6			62	267.47	55.91	18.49	1:5.8
143	Maplecroft Gem................	7	2	4	4	2	n 7	26	25	8		C. 25	58	266.56	57.35	17.35	1:4.2
144	Sitje Twisk Pietertje...........	$2\frac{4}{7}$	$2\frac{4}{7}$			$1\frac{2}{7}$	b $3\frac{6}{7}$	$10\frac{2}{7}$				Pasture		64.44			1:3.3
145	Inka 8th......................			$1\frac{3}{5}$			l $5\frac{1}{5}$	$6\frac{4}{5}$				"		42.04			1:5.4
146	Clothilde Artis Topsy*						t 4	4				"		25.20			1:2.7
147	Segis Inka.....................	$7\frac{9}{16}$			$\frac{15}{16}$	$\frac{15}{16}$	b $7\frac{9}{16}$	17				"		107.46			1:3.1

148	Netherland Sada	2 1/5	3 1/5	3		1	o 1 1/5	10 3/5				Pasture		66.94			1:5.3
149	Bibiana's Pet	2 1/5	3 1/5	3		1	o 1 1/5	10 3/5				"		66.94			1:5.3
150	Aaggie B.	2 1/5	3 1/5	3		1	o 1 1/5	10 3/5				"		66.94			1:5.3
151	Netherland Hengerveld	2	3	2 5/7		6/7	o 1 1/7	9 5/7				"		60.93			1:5.3
152	Inka Hartog	2	3	2		1	1	9				"		55.37			1:5.3
153	Jessie Beets	2 1/5	3 1/5	3		1	o 1 1/5	10 3/5				"		66.94			1:5.3
154	7th Durkje Veeman's Ruby	2	3	2 5/7		1	o 1	9 5/7				"		60.93			1:5.3
155	Aegis 10th	9½	6	4¾			b 5	25¼				"		158.76			1:4.6
156	Clothilde 6th	9½	6	4¾			b 5	25¼				"		158.76			1:4.6
157	Idene Rooker	9½	6	4¾			b 5	25¼				"		158.76			1:4.6
158	Executrix Netherland	9½	6	4¾			b 5	25¼				"		158.76			1:4.6
159	Netherland Wayne	15	12	7	4¼	5		43¼	25		5	S. 30	60	392.49	90.02	30.74	1:4.5
160	Mutual Friend 2d	18	15	8	6½	6		53½	30		1½	S. 27½	59	432.82	73.97	21.00	1:4.2
161	Plum 4th	8¾	3⅝	2		5⅝		20	40	10		P. 12	62	260.54	62.18	16.78	1:4.9
162	Helena Burke	12¾	3⅝	2		5⅝		24	40	10		P. 12	62	311.81	60.16	20.66	1:4.1
163	Aaggie 3d's Wayne	7	7	4	8	12		38	36	3		R. 40	79	394.17	80.93	25.09	1:3.3
164	Inka Hartog	4½	4	2				10½		2		Pasture		76.86			1:5.6
165	Plum 4th	4½	4	2				10½		2		"		76.86			1:5.6
166	Netherland Wayne	9	5¾	5¾	8¾	5¾		35	37		4	S. 25	66	345.73	77.44	27.71	1:3.7
167	Concordia 2d	9	5¾	5¾	8¾	5¾		35	37		4	S. 25	66	345.73	73.57	22.75	1:3.7
168	Mutual Friend 2d's Wayne	9	5¾	5¾	8¾	5¾		35	37		4	S. 25	66	345.73	65.91	19.32	1:3.7
169	Concordia 2d's America	9	5¾	5¾	8¾	5¾		35	37		4	S. 25	66	345.73	88.06	29.88	1:3.7
170	Star's Netherland	9	5¾	5¾	8¾	5¾		35	37		4	S. 25	66	345.73	73.84	20.73	1:3.7
171	Aaggie 3d's Wayne	14	9	7½	7½	5¼		43¼	30		7½	S. 34	71½	423.33	85.17	25.53	1:3.9
172	Netherland VanFriesland Beets	6	2½	1½		3½	e 1½	15		6		P. 8	Pasture	141.05			1:4.4
173	Magadora	6	2½	1½		3½	e 1½	15		6		P. 8	"	141.05			1:4.4
174	Netherland Hengerveld	8	3	2		4	e 2	19		6		P. 8	"	165.76			1:4.3
175	Minnie Maria	9					b 4½	13½					"	84.42			1:3.8
176	Segis Aaggie 2d	9					b 4½	13½					"	84.42			1:3.8
177	Aaggie Grace 2d's Pietertje	13					f 5	18					"	113.61			1:4.0
178	Sweet Bough	3 1/5				1/5	r 7 3/5	12					"	74.69			1:3.7
179	Patty's Pet	3½	3½			3½	a 7	17½				P. 15	"	132.02			1:3.4
180	Maid of Eaton Inka	3½	3½			3½	a 7	17½				P. 15	"	132.02			1:3.4
181	Sadie Vale 2d	10	6	3	2 2/5	2 3/5		24	72		5		77	282.66	87.53	27.98	1:5.4
182	Mutual Friend 2d	12	9	5	5½	5		36½	72		5		77	358.12	60.95	17.69	1:4.6

*Economic food test.

Number of test.	Name of cow.	Daily ration. Grain. Wheat bran.	Corn meal.	Oats ground.	Cotton-seed meal.	Oil meal.	Miscellaneous.	Total grain.	Coarse fodder. Corn silage.	Hay.	Corn-stalks.	Miscellaneous.	Total coarse fodder.	Dry matter consumed. Total for seven days.	For 100 pounds of milk.	For 1 pou'd of fat.	Nutritive ratio.
183	Aaggie 3d's Wayne.*	3	3 3/7	1 6/7	1 5/7	1 5/7		11 5/7	73 2/7		5		78 2/7	208.20	50.78	14.09	1:6.3
184	Mutual Friend 3d	13	8½	4¾	3	3	g 1¼	33½	49		5½		54½	311.50	72.81	19.08	1:4.7
185	Patty's Pet	5½				4	f 5½	15	22	15		P. 30	67	260.05	57.34	16.05	1:5.9
186	Janie Hijlaard's Inka	5½				4	f 5½	15	22	15		P. 30	67	260.05	58.29	16.97	1:5.9
187	Helena Burke.	8½	4½	3		1¼	i 3	20¼	40	8		P. 10	58	249.97	38.21	12.11	1:6.4
188	Pauline Paul Georgie	9	6	4	4	2	g 1	26	77	5			82	305.83	81.31	23.85	1:5.0
189	Princess of Wayne 7th	9	6	4	4	2	g 1	26	77	5			82	305.83	65.69	20.83	1:5.0
190	Mutual Friend 3d*	2½	2	1½	1	1		8	70	4			74	176.33	48.51	14.46	1:6.6
191	Aaggie Grace's Boy's Topsy	2⅔	1½	1½	⅔	⅓	4⅓	11					Pasture	68.82			1:3.7
192	Patty's Pet *	3⅝				2¾	f 3⅝	10				P. 25	"	93.52			1:5.1
193	Janie Hijlaards Inka	4				3	f 4	11				P. 30	"	106.57			1:5.2
194	Debora's Inka	4				3	f 4	11				P. 30	"	106.57			1:5.2
195	Vroukje of Hijlaard 7th	3				2¼	f 3	8¼				P. 15	"	65.48			1:4.8
196	Creamella 2d	4				3	f 4	11				P. 30	"	106.57			1:5.2
197	Aaggie Grace 2d's Pietertje	5		5			f 10	20					"	126.56			1:3.5
198	Sadie Vale 2d	11	7	4	4	2		28	60		6		66	295.47	86.84	25.35	1:5.1
199	Inka Pietertje Mechthilde	10		3			l 10	23	30	6		C. 15	51	234.64	57.24	18.60	1:5.8
200	Shadeland Angie.	8	2½	5		2½	d 8	26	25	8		C. 25	58	265.09	62.54	21.48	1:5.5
201	Sadie Vale Concordia*	6 3/7	8 3/7	5 3/7	4	4		28 2/7	66	7			73	315.13	58.11	18.79	1:4.9
202	Mutual Friend 3d*	6 3/7	2 1/7	5/7	½			9 11/14	62	5 1/7			67 1/7	179.24	41.93	11.49	1:6.6
203	Princess of Wayne 7th	7	10	7	3	2		29	56	6			62	285.04	58.00	18.27	1:5.3
204	Shadeland Ruby 5th	7	2	4	4	2	n 7	26	25	8		C. 25	58	266.56	60.12	21.32	1:4.2
205	Vrouwkje of Hijlaard 7th	2¼	2¼			1⅛	b 3 3/8	9				Pasture		55.94			1:3.3
206	Jannek Bright 2d		2	1 3/5	4/5		r 7 3/5	12				"		75.46			1:3.5
207	Aaggie Grace's Boy's Topsy		2	1 3/5	4/5		r 7 3/5	12				"		75.46			1:3.5
208	Jannek Beauty's Inka Pietertje		2	1 3/5	4/5		r 7 3/5	12				"		75.46			1:3.5
209	Segis Aaggie 2d's Pietertje	6¾			⅞	⅞	b 6 3/4	15				"		94.85			1:3.1
210	Shadeland Amber	6					a 6	12				"		74.97			1:2.9

* Economic food test.

Foods mentioned under the head of "Miscellaneous" in Table II are indicated as follows: a. Gluten meal; b. Gluten feed; c. Pea meal; d. Buckwheat, ground; e. Barley; f. Hominy chop; g. Linseed bran; h. Buckwheat feed; i. Peas and barley ground; l. Peas, barley and buckwheat; n. Peas and buckwheat; o. Rye; r. Gluten feed, malt sprouts and hominy chop; t. Gluten feed and malt sprouts; C. Carrots; P. Potatoes; S. Clover silage; R. Green clover.

SUMMARY OF TABLE II.

A. SHOWING THE VARYING PRODUCTION FROM SAME AMOUNTS AND KINDS OF FOOD BY ANIMALS OF SIMILAR AGES.

Number in tables I and II.	Age.	Total dry matter consumed.	Total pounds of milk.	Average per cent fat.	Total pounds of fat.	Dry matter for 100 pounds milk.	Dry matter for 1 pound. fat.
20	2	282.87	354.188	2.96	10.478	79.83	26.97
23	2	282.87	243.125	3.24	7.879	116.35	35.81
95	3	204.82	228.625	3.35	7.665	89.58	26.72
99	3	204.82	358.438	3.62	12.978	57.14	15.77
138	4	247.24	398.500	3.01	12.015	62.04	20.57
140	4	247.24	302.813	3.52	10.648	81.65	23.30
168	5	345.73	524.563	3.41	17.888	65.91	19.32
169	5	345.73	392.563	2.95	11.568	88.06	29.88

B. SHOWING THE VARYING PRODUCTION FROM SIMILAR AMOUNTS OF FOOD BY ANIMALS OF DIFFERENT AGES.

Number in tables I and II.	Age.	Total dry matter consumed.	Total pounds of milk.	Average per cent fat.	Total pounds of fat.	Dry matter for 100 pounds milk.	Dry matter for 1 pound. fat.
10	2	288.12	236.438	2.87	6.780	121.85	42.49
24	2	282.87	325.500	3.15	10.209	86.90	27.71
98	3	298.62	364.188	2.97	10.810	81.99	27.62
101	3	285.04	520.188	3.06	15.903	54.79	17.92
118	4	285.46	339.875	3.23	10.972	83.99	26.01
143	4	266.56	464.750	3.30	15.357	57.35	17.35
181	7	282.66	322.813	3.13	10,099	87.53	27.98
203	6	285.04	491.438	3.17	15.600	58.00	18.27

C. SHOWING THE VARYING QUANTITIES OF FOOD REQUIRED TO PRODUCE SIMILAR AMOUNTS OF BUTTER FAT IN DIFFERENT ANIMALS.

Number in tables I and II.	Age.	Total pounds of fat.	Total dry matter consumed.	Total pounds of milk.	Average per cent fat.	Dry matter for 100 pounds of milk.	Dry matter for 1 pound fat.
26	2	8.538	332.68	239.625	3.56	138.83	38.96
45	2	8.508	226.73	315.875	2.69	71.78	26.65
92	3	8.846	338.80	310.625	2.85	109.07	38.30
44	2	9.111	227.01	290.375	3.14	78.18	24.92
22	2	9.082	282.87	242.500	3.75	116.64	31.14
8	2	11.116	341.67	317.625	3.50	107.57	30.73
59	2	11.747	204.82	312.188	3.76	65.61	17.35
78	3	11.348	285.46	349.125	3.25	81.76	25.15
79	3	11.406	394.17	344.875	3.30	114.29	34.56
161	6	15.519	260.54	419.000	3.70	62.18	16.78
163	7	15.705	394.17	487.063	3.22	80.93	25.09
160	7	20.608	432.82	585.125	3.52	73.97	21.00
187	7	20.364	249.97	654.125	3.11	38.21	12.11

D. SHOWING THE VARYING QUANTITIES OF FOOD REQUIRED TO PRODUCE THE LARGEST AMOUNTS OF MILK IN ANIMALS OF DIFFFRENT AGES.

Number in tables I and II.	Age.	Total pounds of milk.	Total dry matter consumed.	Total pounds fat.	Average per cent fat.	Dry matter for 100 pounds milk.	Dry matter for 1 pound fat.
20	2	354.188	282.87	10.487	2.96	79.83	26.97
38	2	334.395	230.65	9.339	2.79	68.98	24.69
82	3	414.500	423.33	14.485	3.50	102.12	29.22
101	3	520.188	285.04	15.903	3.06	54.79	17.92
133	4	466.750	227.01	14.272	3.05	48.64	15.91
134	4	494.250	305.83	18.103	3.66	61.88	16.89
160	7	585.125	432.82	20.608	3.52	73.97	21.00
162	5	518.250	311.81	15.089	2.91	60.16	20.66
168	5	524.563	345.73	17.888	3.41	65.91	19.32
182	9	589.250	358.12	20.242	3.44	60.95	17.69
187	7	654.125	249.97	20.364	3.11	38.21	12.11

E. SHOWING LARGEST AND SMALLEST QUANTITIES OF FOOD REQUIRED TO PRODUCE 100 POUNDS OF MILK IN DIFFERENT ANIMALS EXCLUSIVE OF "FOOD TESTS."

Number in tables I and II.	Age.	Dry matter for 100 pounds of milk.	Total dry matter consumed.	Dry matter for 1 pound of fat.	Total pounds of milk.	Average per cent fat'	Total pounds of fat.
57	2	141.75	221.83	41.47	156.500	3.39	5.301
60	2	60.28	196.28	20.98	325.625	2.87	9.354
79	3	114.29	394.17	34.56	344.875	3.30	11.406
101	3	54.79	285.04	17.92	520.188	3.06	15.903
141	4	94.46	298.62	34.56	316.125	2.73	8.640
133	4	48.64	227.01	15.91	466.750	3.05	14.272
159	5	90.02	392.49	30.74	436.000	2.93	12.767
187	7	38.21	249.97	12.11	654.125	3.11	20.364

F. SHOWING THE LARGEST AND SMALLEST QUANTITIES OF FOOD REQUIRED TO PRODUCE ONE POUND OF FAT IN DIFFERENT ANIMALS EXCLUSIVE OF "FOOD TESTS."

Number in tables I and II.	Age.	Dry matter for 1 pound of fat.	Total dry matter consumed.	Dry matter for 100 pounds of milk.	Total pounds of milk.	Average per cent fat.	Total pounds of fat.
9	2	45.27	312.62	126.56	247.000	2.80	6.906
59	2	17.35	204.82	65.61	312.188	3.76	11.747
92	3	38.30	338.80	109.07	310.625	2.85	8.846
99	3	15.77	204.82	57.14	358.438	3.62	12.978
118	4	26.01	285.46	83.99	339.875	3.23	10.972
133	4	15.91	227.01	48.64	466.750	3.05	14.272
159	5	30.74	392.49	90.02	436.000	2.93	12.767
187	7	12.11	249.97	38.21	654.125	3.11	20.364

G. SHOWING THE AVERAGE PRODUCTION AND CONSUMPTION OF ALL ANIMALS TESTED WHILE NOT AT PASTURE AND OF EACH AGE SEPARATELY.

	No. of animals.	Milk.	Per cent fat.	Pounds fat	Dry matter consumed.	Dry matter for 100 pounds milk.	Dry matter for 1 pound fat.
Two-year olds.	27	274.326	3.18	8.726	260.55	94.98	29.86
Three-year olds	19	355.036	3.26	11.570	304.20	85.68	26.29
Four-year olds.	12	406.036	3.29	13.366	273.12	67.06	20.43
Full aged cows	28	458.362	3.27	14.975	303.70	66.26	20.28
Average of all	86	370.454	3.25	12.036	286.00	77.20	23.76

H. ECONOMIC FOOD TESTS.

Number in tables I and II.	Age.	Total pounds of milk.	Average per cent fat.	Total pounds of fat.	Total dry matter consumed.	Dry matter for 100 pounds milk.	Dry matter for 1 pound fat.
39	2	305.188	3.32	10.043	166.02	54.39	16.53
183	9	410.000	3.64	14.773	208.20	50.78	14.09
190	5	363.875	3.34	12.184	176.33	48.51	14.46
201	5	542.313	3.09	16.772	315.13	58.11	18.79
202	6	427.438	3.44	14.724	179.24	41.93	11.49

There is much variation in the amount of food eaten by different animals during a test, and a close study of Tables I and II will be of interest and value to every cattle feeder: Study Table I to see what a particular cow produced in a week and Table II to find what she ate during the same time. The cows tested while at pasture were all given more or less grain, and the amounts vary from $6\frac{4}{5}$ to $17\frac{3}{5}$ pounds per day for two-year olds; from $7\frac{1}{2}$ to 21 pounds for three-year olds; from $6\frac{4}{5}$ to $25\frac{1}{4}$ pounds for four-year olds; and from 9 to $25\frac{1}{4}$ pounds for full aged cows. The cows tested while on stall feed naturally ate more grain and these amounts vary from 14 to $37\frac{1}{4}$ pounds for two-year olds; from 18 to $43\frac{1}{4}$ pounds for three-year olds; from $16\frac{3}{4}$ to 35 pounds for four-year olds, and from 15 to $53\frac{1}{2}$ pounds for full aged cows. In amount of coarse fodder eaten daily, two-year olds vary from 42 to $71\frac{1}{2}$ pounds; three-year olds from 41 to $71\frac{1}{2}$ pounds, four-year olds from 33 to 92 pounds; and full aged cows from $54\frac{1}{2}$ to 82 pounds. Animals under "Economic Food Test" are not included in the above.

Such large rations of grain and of coarse fodder are, no doubt, surprising to the general dairyman, and he will gravely question the economy of feeding so heavily. However, the question with the men who have entered their cows in these tests is not one of economy so much as it is of forcing the cow to produce as much milk and butter as possible. In order to do this, a large amount of food is necessary, and the more food she can consume and

digest the larger product she is apt to give. The fame the cow brings to the herd and the prize she wins, and not the milk and butter, are to pay for the food. It is a question whether the "Economic Food Test," where the attempt is to feed as little and produce as much as possible, is a step in the right direction. Would it not be a better principle to, in some way, bring out those animals which can make the most economic use of *large* amounts of food?

Under the head of "Summary of Table II" we have gathered such data as will show the great variation in production from the same or similar amounts of food when given to different animals. As a matter of convenience, when referring to the figures in the summary we shall omit fractions as much as possible and speak in round numbers.

Under A are arranged two animals from each of the various ages which consumed the same amounts of the same kinds of food, together with their production of milk and fat. Each two animals were in the same herd and were tested at the same time. Of the two-year olds, numbers 20 and 23 each consumed 282.87 pounds of dry matter, but in production No. 20 exceeds No. 23 by about 111 pounds of milk, or 45 per cent, and over 2.5 pounds of fat, or 33 per cent. Number 20 also required 36.5 pounds less of dry matter for 100 pounds of milk and nearly 9 pounds less of dry matter for 1 pound of fat than No. 23. Of the three-year olds numbers 95 and 99 each consumed 204.82 pounds of dry matter. The difference in production is about 130 pounds of milk or 57 per cent, and 5.3 pounds of fat or 69 per cent in favor of No. 99. The latter required about 32 pounds less of dry matter for 100 pounds of milk and 11 pounds less of dry matter for 1 pound of fat than No. 95.

Among the four-year olds numbers 138 and 140 each consumed 247.24 pounds of dry matter. From this No. 138 produced 95 pounds or 31 per cent more of milk and 1.367 pounds or 13 per cent more of fat than No. 140. Number 138 also required 19.6 pounds less of dry matter for 100 pounds of milk and 2.7 pounds less of dry matter for 1 pound of fat than No. 140.

Of the full aged cows numbers 168 and 169 each consumed 345.73 pounds of dry matter, but No. 168 produced 132 pounds

or 33 per cent more of milk amd 6.32 pounds or 54 per cent more of fat than No. 169. Number 168 required 23 pounds less of dry matter for 100 pounds of milk and 10.5 pounds less of dry matter for 1 pound of fat.

Under B are arranged the records of eight cows selected from the various ages, each of whom consumed in the neighborhood of 285 pounds of dry matter. In production they vary from 236 to 520 pounds of milk and from 6.78 to 15.9 pounds of fat, or a variation of 120 per cent in milk and of 134 per cent in fat. In the amount of dry matter required for 100 pounds of milk they vary from 55 to 122 pounds or 122 per cent, and for 1 pound of fat from 17.35 to 42.5 pounds or 145 per cent.

Under C is collected some data showing the varying amounts of food required to produce similar amounts of butter-fat in different animals. For the production of about 8.5 pounds of butter-fat in two-year olds, the dry matter varies from 226 to 332 pounds, a difference of 46 per cent. To produce a little over 11 pounds of fat is required a quantity of dry matter varying from 204 to 341 pounds, a difference of 67 per cent. For a similar amount of fat among three-year olds, the consumption of dry matter varies from 285 to 394 pounds, a difference of 38 per cent.

Among full aged cows the amount of dry matter required to produce about 15.5 pounds of fat varies from 260 to 394 pounds, a difference of 51 per cent. To produce a little more than 20 pounds of fat, the variation is still greater, being the difference between 250 and 433 pounds or 73 per cent.

Under D are arranged the records of the cows which gave the most milk for their age of those that were stall fed. Among two-year olds a difference of a little less than 20 pounds of milk is accompanied with a difference of over 52 pounds of dry matter, the heifer consuming the most food giving the most milk. This order is reversed among three-year olds where a difference in milk yield of a little more than 105 pounds, is accompanied with a difference of over 138 pounds or 48 per cent of dry matter consumed, but the heifer consuming the larger amount of food gave the less milk yield. The variation among four-year olds in milk yield is 27½ pounds and in dry matter consumed a little over 78 pounds, or 34 per cent, and the cow giving more milk also con-

sumed the larger amount of food. Five records of old cows are given. In milk production these vary from 518 to 654 pounds, and these same two records vary in dry matter consumed from 312 to 250 pounds respectively. Here again, as among the three-year olds, the larger yield of milk is accompanied with the smaller consumption of food. It should be added that these two records were made by the same cow, Helena Burke, one at five years of age and the other at seven. She shows a better capacity for the economic use of food at seven than at five. Indeed, she and No. 101, America 2d's Pauline DeKol among three-year olds are remarkable animals in this respect as well as in the large records they have made for milk and butter.

Under E we have a vivid comparison of the largest and smallest amounts of food required to produce 100 pounds of milk in different animals. Among the two-year olds No. 57 required 141 pounds of dry matter to produce 100 pounds of milk, which is the most required by any cow of any age. It may be said in her favor that she was not in good condition. She was so hard a milker that it was necessary to use the knife to enlarge the orifices of the teats which were not healed at the time of test, thus rendering the milking operation very uncomfortable to her and doubtless reducing the quantity. The two-year old requiring the smallest amount of dry matter for 100 pounds of milk is No. 60 The difference between the largest and smallest amounts is 81 pounds or 135 per cent. In like manner, we find that the difference between the largest and smallest amounts required by three-year olds is 60 pounds or 180 per cent, by four-year olds about 46 pounds or 94 per cent, and by full aged cows nearly 52 pounds or 136 per cent.

Under F are shown the largest and smallest amounts of food required to produce one pound of fat in different animals at various ages. For two-year olds the difference between these amounts is about 28 pounds of dry matter or 160 per cent, for three-year olds 21.5 pounds or 136 per cent, for four-year olds 10 pounds or 63 per cent, and for full aged cows over 18 pounds or 154 per cent.

Summing up the observations under E and F, we find the order of the per cent of variation from the largest to the smallest

amounts of food required by different animals of the same age, is the same in regard to the production of fat as in the production of milk, namely, the largest variation is found among two year olds, next come full aged cows, then three-year olds, and the least variation is among four-year olds. As regards the variation in actual pounds of dry matter, the order is, two and three-year olds, full aged cows and last, four-year olds.

Three cows are named in both E and F. Number 133, Clothilde Artis Belle has the distinction of requiring less food for 100 pounds of milk and also for one pound of fat than any other four-year old. Number 159, Netherland Wayne, required more food for the same amount of milk and fat than any other aged cow. Number 187, Helena Burke, required less food for the same amount of milk and fat than any other aged cow.

Under G are given the average production and consumption of all the animals that were tested on stall feed. In the order of production of milk and fat they stand in the order of age, the two-year olds averaging the least and the full aged cows the most. In average consumption of food, however, the three-year olds are the highest, being a trifle more than full aged cows, after which follow four and two-year olds respectively. In amount of dry matter for 100 pounds of milk and one pound of fat, full aged cows require the least and are followed successively by four, three and two-year olds. From these averages it would seem that full aged cows lead in economic production although they are so closely followed by four-year olds as to make the difference of little or no account.

"ECONOMIC FOOD TESTS."

Under H are arranged the records of five cows that were entered in the "Economic Food Tests." The Holstein-Friesian Association gives prizes to the cows producing butter at the least cost per pound for food. A list of all the more common cattle foods with a schedule of prices is given, and each breeder is at liberty to choose any of these with which he thinks he can produce butter the cheapest through his particular animal. These prizes have been offered for only two years and in this state six cows have been entered for them. One cow, No. 146, was en-

tered on grass and her record does not appear in our list because no just comparison can be made as to the amount of dry matter consumed which is the basis of this comparison. Numbers 190 and 202 refer to the same cow, Mutual Friend 3d, she being tested in two successive years. On her last test she consumed the least amount of food for one pound of fat that has been required by any cow of any age whose record is given in this bulletin. It will be remembered under F that No. 187 required the least dry matter for 100 pounds of milk and one pound of fat of any cow not on an "Economic Food Test." This is only a little more food for a pound of fat than was required by No. 202, and the former was not entered for a food test, but it was intended to give her all the food she could well handle. This is well shown in tabular form below.

		Food consumed per day.		Dry matter consumed.	
		Forage.	Grain.	For 100 lbs. milk.	For 1 lb fat.
No. 202.	Mutual Friend 3d .... (On Economic Food Test)	67 1/7	9 11/14	41.93	11.49
No. 187.	Helena Burke .... (Cow requiring least dry matter for 1 lb. product)	58	20¼	38.21	12.11
No. 160.	Mutual Friend 2d .... (Cow consuming most dry matter per day.)	59	53½	73.97	21
	Average for all cows not at pasture			77.20	23.76

On the food test, the only two-year old entered required 16.53 pounds of dry matter for one pound of fat. This is a little more than was required by the three- and four-year olds, numbers 99 and 133 respectively, and only a little less than by No. 59 of the two-year olds. Neither of the three last named were entered on food tests. The cow requiring the most dry matter for one pound of fat among those entered for food tests is No. 201, with 18.79 pounds. It will be noticed, however, that she consumed

a large total amount of food, it being 315.13 pounds. Had she given milk of as high a per cent of fat as when a four-year old, No. 134, or when a three-year old, No. 82, she would have produced her fat much cheaper.

VARIATION IN PER CENT FAT.

Table III contains such data as could be obtained from the records concerning the per cent of fat and its variation in different animals. Each record given here bears the same number as corresponds to the animal in Tables I and II which bears that record. The data given contains the number of days from calving to the beginning of the test, the average per cent of fat for the week, the highest per cent of fat, the time of day at which it was obtained, and the number of hours which elapsed between that time and the previous milking; also the same data concerning the lowest per cent of fat, and the range of variation in per cent of fat.

TABLE III.

VARIATION IN PER CENT OF FAT.

A. Two-Year Olds.

No. in tables I and II.	Days from calving.	Av'ge per cent fat.	High'st per cent fat.	Time of milking.	Hours from previous milking.	Lowest per cent fat.	Time of milking.	Hours from previous milking.	Range of variation.
TESTS WHICH BEGAN 1 TO 15 DAYS FROM CALVING.									
5	7	2.29	3.45	night.	5	1.40	morn.	11¼	2.05
30	11	3.24	3.90	"	6	2.30	"	9½	1.60
36	15	3.24	3.80	noon.	7	2.90	night.	7½	.90
50	15	3.34	3.90	"	7½	2.80	morn.	9½	1.10
51	6	3.48	3.80	"	7	3.30	morn and night	8, 9	.50
Average 3.12									1.23
TESTS WHICH BEGAN 16 TO 30 DAYS FROM CALVING.									
7	28	2.76	3.60	night.	5	2.00	noon.	7¾	1.60
8	28	3.50	3.90	noon.	7½	3.20	morn and night	9, 7½	.70
9	24	2.80	3.20	"	7½	2.50	night and morn	9, 7½	.70
12	26	3.12	4.20	"	7	1.90	morn.	10	2 30
22	22	3.75	5.25	"	7½	3.05	"	9½	2.20
23	21	3.24	4.40	"	7½	2.50	"	9½	1.90
24	25	3.15	3.70	night.	7	2.60	noon.	7½	1.10
25	20	3.17	3.70	"	7	2.80	morn.	9½	.90
28	24	2.82	3.60	"	6	2.10	"	9½	1.50
31	16	4.22	4.80	"	6	3.70	morn and noon.	9½	1.10
38	21	2.79	3.55	noon.	7½	2.15	morn.	9	1.40
44	23	3.14	3.70	midnight.	6	2.70	6 a. m.	6	1.00
48	26	3.21	3.70	noon.	7½	2.70	morn.	9½	1.00
46	27	3.46	4.10	noon.	7½	2.90	"	9½	1.20
52	18	2.37	2.70	noon and morn.	7, 9	2.10	night.	8	.60
56	20	3.65	5.10	night.	7	1.70	morn.	9	3.40
59	30	3.76	5.00	"	7	2.40	"	9	2.60
60	30	2.87	3.40	10 a. m.	6	2.30	4 p. m.	6	1.10
69	23	3.00	5.20	noon.	7	2.00	morn.	9	3.20
65	30	2.74	4.40	"	8	1.80	"	9	1.60
67	22	2.86	3.60	morn.	8	1.60	noon.	8	2.00
68	21	2.99	4.10	"	8	2.20	morn.	8	1.90
Average 3.15									1.59
TESTS WHICH BEGAN 31 TO 60 DAYS FROM CALVING.									
2	36	3.08	4.00	night.	5½	2.10	morn.	10½	1.90
3	43	3.00	4.50	"	5½	1.70	"	10½	2.80
6	32	3.00	3.65	"	5	2.20	noon.	7¾	1.45
10	49	2.87	3.40	noon.	7½	2.20	morn.	9	1.20
11	53	3.30	3.80	"	7½	2.80	night.	7½	1.00
13	34	2.90	4.85	"	7	2.00	morn.	9	2.85

TESTS WHICH BEGAN 31 TO 60 DAYS FROM CALVING.—*Continued.*

No. in tables I and II.	Days from calving.	Av'ge per cent fat.	High'st per cent fat.	Time of milking.	Hours from previous milking.	Lowest per cent fat.	Time of milking.	Hours from previous milking.	Range of variation.
14	40	2.95	3.10	morn and noon.	9, 7	2.70	night.	8	.40
15	42	3.35	3.85	noon.	6½	2.90	morn.	10	.95
17	51	3.20	4.00	"	6½	2.45	"	10	1.55
19	58	3.45	4.10	"	6½	3.05	"	10	1.05
21	48	3.24	3.80	"	7½	2.80	"	9½	1.00
26	51	3.56	4.80	night.	7	3.00	"	9½	1.80
27	57	3.37	4.00	night and noon	7, 7½	2.80	"	9½	1.20
29	47	3.15	4.30	night.	6	2.30	"	9½	2.00
47	34	3.47	4.40	noon.	7½	2.40	"	9½	2.00
49	46	3.05	3.80	"	7½	2.30	"	9½	1.50
45	40	2.69	3.30	night.	7	2.30	morn and noon	9½, 7½	1.00
53	35	2.92	3.50	noon.	7	2.40	night.	8	1.10
57	49	3.39	3.70	night.	7	3.00	morn.	9	.70
58	55	2.88	3.60	"	7	2.40	"	9	1.20
70	31	3.16	5.40	noon.	7	1.80	"	9	3.60
63	45	2.68	3.10	"	8	2.30	"	9	.80
64	46	2.79	3.40	"	8	2.30	"	9	1.10
66	38	3.07	4.80	"	8	2.40	night.	7	2.40
71	40	2.86	3.30	"	7	2.60	night and morn	8, 9	.70
72	50	3.13	3.60	morn.	9	2.80	night.	8	.80
73	50	2.95	4.00	noon.	7	2.30	morn.	9	1.70
74	47	2.87	3.80	"	7	2.50	"	9	1.30
62	41	2.69	3.00	"	8	2.30	"	9	.70
Average		3.07							1.44

TESTS WHICH BEGAN MORE THAN 60 DAYS FROM CALVING.

No. in tables I and II.	Days from calving.	Av'ge per cent fat.	High'st per cent fat.	Time of milking.	Hours from previous milking.	Lowest per cent fat.	Time of milking.	Hours from previous milking.	Range of variation.
1	81	3.36	3.75	noon.	8	2.85	morn.	10½	.90
4	63	3.72	4.60	night.	5½	2.50	"	10½	2.10
16	61	3.25	3.50	"	7½	3.00	noon.	6½	.50
18	61	3.40	4.75	"	7½	2.50	morn.	10	2.25
20	68	2.96	3.60	"	7	2.30	"	9½	1.30
32	97	2.66	3.10	noon.	7	2.40	"	9½	.70
33	74	3.13	3.70	"	7	2.80	"	9½	.90
34	78	2.93	3.60	"	7	2.60	"	9½	1.00
35	84	3.28	4.20	"	7	2.90	"	9½	1.30
37	86	3.01	3.40	"	7	2.70	"	9½	.70
39	105	3.32	4.50	"	8	2.70	"	9	1.80
40	72	3.50	4.70	night.	7	2.80	"	9	1.90
41	85	3.32	3.90	"	7	2.80	"	9	1.10
42	85	2.96	3.80	noon.	7½	2.40	"	9	1.40
43	90	3.12	3.40	"	7½	2.80	"	9	.60
54	112	2.91	3.90	"	8	2.00	"	10	1.90
55	107	3.17	3.80	"	8	2.60	"	10	1.20
61	84	2.79	3.40	10 p. m.	6	2.40	4 p. m.	6	1.00
Average		3.15							1.25
" all 2 yr. olds.		3.12							1.42

B. Three-Year Olds.

No. in tables I and II.	Days from calv-ing.	Av'ge per cent fat.	High'st per cent fat.	Time of milking.	Hours from previ-ous milk-ing.	Lowest per cent fat.	Time of milking.	Hours from previous milking.	Range of varia-tion.
TESTS WHICH BEGAN 1 TO 15 DAYS FROM CALVING.									
75	5	4.24	5.40	noon.	8	3.70	morn.	10½	1.70
78	11	3.25	4.00	night.	7	2.10	"	10	1.90
79	15	3.30	3.90	"	7	2.85	night.	7	1.05
80	12	3.45	4.70	noon.	7	2.40	morn.	9	2.30
91	12	2.94	4.30	night.	6	2.30	"	10	2.00
105	14	3.96	5.10	noon.	7	3.50	"	9½	1.60
Average		3.52							1.76
TESTS WHICH BEGAN 16 TO 30 DAYS FROM CALVING.									
76	17	4.27	4.90	noon.	7½	3.60	morn.	9	1.30
88	30	3.21	3.70	"	7½	2.30	"	9½	1.40
85	18	3.61	4.20	"	7½	3.10	"	9½	1.10
99	25	3.62	5.20	night.	7	2.00	"	9	3.20
98	17	2.97	3.20	noon and night	7, 8	2.60	noon.	8	.60
100	27	3.18	3.80	10 p. m.	6	2.60	10 a. m.	6	1.20
101	27	3.06	4.00	"	6	2.40	4 p. m.	6	1.60
104	21	3.12	3.60	noon.	7	2.80	night.	7½	.80
106	25	3.19	3.50	"	7	2.90	morn.	9½	.60
109	20	3.20	3.90	"	7	2.80	night.	8	1.10
110	27	3.44	4.40	"	7	2.70	morn.	9	1.70
112	23	2.75	3.40	6 a. m.	6	2.00	6 p. m.	6	1.40
Average		3.30							1.33
TESTS WHICH BEGAN 31 TO 60 DAYS FROM CALVING.									
77	42	3.59	4.40	noon.	7½	2.80	morn.	9	1.60
82	56	3.50	4.00	night.	7	2.90	"	9½	1.10
83	50	3.08	3.55	morn.	8	2.55	noon.	8½	1.00
89	58	2.90	4.10	noon.	7½	2.20	morn.	9½	1.90
90	48	3.08	4.00	"	7½	1.70	"	9½	2.30
86	47	2.90	4.00	night.	7	2.10	"	9½	1.90
87	51	3.02	3.80	"	7	2.20	"	9½	1.60
92	45	2.85	3.50	"	7	2.60	"	9	.90
94	55	3.18	3.70	"	7	2.90	"	9	.80
96	31	2.56	3.20	"	7	2.00	"	9	1.20
97	31	2.84	3.60	noon.	8	2.10	"	9	1.50
103	41	2.89	3.50	"	8	2.10	"	9	1.40
107	38	3.11	3.50	"	7	2.70	"	9½	.80
111	38	2.69	3.90	"	7	2.00	"	9	1.90
Average		3.01							1.44

No. in tables I and II.	Days from calving.	Ave'ge per cent fat.	High'st per cent fat.	Time of milking.	Hours from previous milking.	Lowest per cent fat.	Time of milking.	Hours from previous milking.	Range of variation.
TESTS WHICH BEGAN MORE THAN 60 DAYS FROM CALVING.									
81	65	3.40	4.80	night.	7½	1.90	morn.	10	2.90
93	68	3.43	4.20	"	7	2.80	"	9	1.40
102	74	3.22	4.20	10 a.m.	6	2.40	4 a.m.	6	1.80
84	78	2.60	3.30	noon.	7½	2.20	morn.	10	1.10
95	78	3.35	3.60	night.	7	3.00	"	9	.60
108	64	3.45	4.40	noon.	7	2 30	"	9½	2.10
Average . . 3.24									1.65
Avg. all 3-yr. olds. 3.22									1.48
C. Four-Year Olds. TESTS WHICH BEGAN 1 TO 15 DAYS FROM CALVING.									
118	12	3.23	3.90	night.	7	2.90	noon.	7	1.00
121	15	4.27	5.80	"	7	3.25	morn.	9½	2.55
122	6	2.91	3.30	morn.	8	2.55	noon.	8½	.75
133	14	3.05	3.80	6 p.m.	6	2.30	6 a.m.	6	1.50
134	13	3.66	4.40	noon.	7½	3.00	morn.	9½	1.40
139	10	3.02	3 60	"	8	2.30	"	8	1.30
140	10	3.52	4.50	morn.	8	2.80	night.	8	1.70
143	12	3.30	4.00	noon.	8	2.50	morn.	8	1.50
141	13	2.73	3.70	"	8	1.70	"	9	2.00
Average . . . 3.30									1.52
TESTS WHICH BEGAN 16 TO 30 DAYS FROM CALVING.									
130	14	3.19	4.65	night.	5½	1.95	morn.	10½	2.70
131	30	2.59	3.10	noon.	7½	2.20	"	9	.90
137	18	3.24	4.90	night.	6	2 40	"	10	2.50
136	28	2.89	4.60	"	6	1.80	"	10	2.80
138	29	3.01	3.50	noon.	8	2.20	"	8	1.30
142	24	3 02	3.60	10 a m.	6	2.40	4 p.m.	6	1.20
145	21	3.40	5.00	noon.	7	2.00	morn.	9	3.00
144	19	3.19	4.70	night.	7	2.30	"	9	2.40
Average . . 3.07									2.10
TESTS WHICH BEGAN 31 TO 60 DAYS FROM CALVING.									
115	57	3.21	4.65	night.	5½	1.95	morn.	10½	2.70
116	36	2.77	3.85	"	5½	2.00	"	10½	1.85
117	50	3.03	4.40	"	5	2.20	"	11¼	2.20
119	31	3.00	4.20	noon.	7	2.20	night.	8	2.00
120	43	2.95	4.55	"	7	1.80	"	8	2.75

No. in tables I and II.	Days from calving.	Ave'ge per cent fat.	High'st per cent fat.	Time of milking.	Hours from previous milking.	Lowest per cent at.	Time of milking.	Hours from previous milking.	Range of variation.
TESTS WHICH BEGAN 31 TO 60 DAYS FROM CALVING.—*Continued.*									
124	54	3.12	3.90	night.	6½	2.50	morn.	10	1.40
126	47	3.09	4.60	“	6½	2.10	“	10	2.50
128	37	3.16	3.70	“	7½	2.70	“	8½	1.00
129	40	2.93	3.50	“	7½	2.40	“	8½	1.10
146	37	3.29	4.40	noon.	7	2.50	“	9½	1.90
147	40	3.11	4.10	“	7	2.40	night.	8	1.70
Average..3.06									1.92
TESTS WHICH BEGAN MORE THAN 60 DAYS FROM CALVING.									
113	83	3.27	4.10	noon.	8	2.40	morn.	10½	1.70
114	62	3.06	3.45	“	8	2.60	“	10½	.85
125	61	2.91	3.60	“	7½	2.20	“	10	1.40
127	104	2.85	3.60	“	7½	2.20	“	10	1.40
132	62	3.86	4.50	“	7½	2.30	“	9	2.20
135	96	3.44	4.40	“	7	2.30	“	9	2.10
123	95	3.14	3.80	“	7½	2.50	“	10	1.30
Average..3.22									1.56
Avg. all 4-yr. olds 3.13									1.76
D. Full Aged Cows. TESTS WHICH BEGAN 1 TO 15 DAYS FROM CALVING.									
152	3	2.83	4.25	night.	5½	2.00	morn.	10½	2.25
157	15	2.56	3.20	“	5	1.80	“	11¼	1.40
162	9	2.91	4.20	“	7	1.70	“	10	2.50
170	9	3.56	4.65	“	7	2.95	“	9½	1.70
173	11	2.84	4.00	“	6	1.70	“	9½	2.30
175	14	2.52	4.40	noon.	8½	1.80	“	8	2.60
176	9	2.83	3.45	“	8½	2.15	night.	7½	1.30
183	8	3.64	4.20	noon and night.	8, 7	2.80	morn.	9	1.40
204	11	2.81	3.40	noon.	8	2.40	night.	8	1.00
Average..2.94									1.83
TESTS WHICH BEGAN 16 TO 30 DAYS FROM CALVING.									
160	22	3.52	4.40	noon.	7½	3.00	morn.	9	1.40
161	20	3.70	4.80	“	7	2.30	“	10	2.50
163	21	3.22	4.20	“	7½	2.60	“	9½	1.60
171	17	3.34	4.10	“	7½	2.90	“	9½	1.20
174	23	3.92	5.70	night.	6	2.40	“	9½	3.30
178	23	3.12	3.90	noon.	7	2.30	“	9½	1.60
182	18	3.44	4.30	“	7½	2.70	“	9	1.60

No. in tables I and II.	Days from calving.	Av'ge per cent fat.	High'st per cent fat.	Time of milking	Hours from previous milking.	Lowest per cent fat.	Time of milking.	Hours from previous milking.	Range of variation.
TESTS WHICH BEGAN 16 TO 30 DAYS FROM CALVING.—*Continued.*									
184	25	3.83	4.60	noon.	8	2.90	morn.	9	1.70
186	30	3.43	4.30	"	7½	2.90	"	9	1.40
185	22	3.57	4.00	"	7½	3.10	"	9	.90
188	30	3.40	4.20	night.	7	3.10	"	9½	1.10
189	30	3.16	4.10	"	7	2.50	"	9½	1.60
194	24	3.08	3.50	noon.	7	2.60	"	9	.90
198	27	3.40	4.20	"	8	2.60	"	9	1.60
201	18	3.09	3.70	10 a. m.	6	2.50	10 p. m.	6	1.20
200	20	2.91	3.70	night.	8	2.20	morn and noon.	8	1.50
Average 3.38									1.57
TESTS WHICH BEGAN 31 TO 60 DAYS FROM CALVING.									
156	33	3.26	4.60	5:15 p. m.	5	2.15	11 p. m.	5¾	3.00
158	46	3.06	4.60	"	5	2.00	4:30 a. m.	5½	3.15
159	59	2.93	3.45	noon.	7½	2.45	morn.	9	1.00
164	35	2.95	4.55	"	7	1 95	night.	8	2.60
166	53	2.79	3.65	"	7½	1.90	morn.	9½	1.75
167	42	3.23	4.70	night.	7	2.20	"	9½	2.50
168	58	3.41	4.40	"	7	2.15	"	9½	2.25
169	60	2.95	3.60	noon.	7½	2.30	"	9½	1.30
180	54	2.66	3.40	"	7½	1.90	"	10	1.50
187	31	3.11	3.90	"	6	2.60	6 a. m.	6	1.30
191	39	2.99	3.70	"	7½	1.90	morn.	9½	1.80
197	34	2.89	4.00	"	8	1.90	"	10	2.10
192	56	3.35	3.70	night.	8	3.00	night.	8	.70
195	38	3.04	4.10	noon.	7	2.30	morn.	9	1.80
196	39	3.12	3.80	night.	8	2.50	"	9	1.30
199	35	3.08	4.40	"	7	2.60	"	9	1.80
202	44	3.44	4.20	10 a. m.	6	2.90	4 p. m.	6	1.30
203	38	3.17	4.60	"	6	2.50	10 p. m.	6	2.10
205	39	3.00	4.20	noon.	8	1.80	morn.	9	1.40
207	54	3.01	3.50	night.	7½	2.40	"	9½	1.10
208	59	3.22	3.80	noon.	7	2.90	"	9½	.90
209	50	2.97	3.70	"	7	2.50	"	9	1.20
Average 3 07									1.72
TESTS WHICH BEGAN MORE THAN 60 DAYS FROM CALVING.									
148	128	3.26	4.60	noon.	8	2.40	morn.	10½	2.40
149	69	3.15	5.00	night.	5½	2.00	"	10½	3.00
150	74	2.91	4.15	noon.	8	2.15	"	10½	2 00
151	65	3.32	3.90	"	8	2.70	"	10½	1.20
153	65	3.46	4.60	night.	5½	2.00	"	10½	2.60
154	68	3.06	4.70	"	5½	1.80	"	10½	2.90
155	343	3.83	6.25	"	5	2.15	"	11¼	4.10

No. in tables I and II.	Days from calving.	Ave'ge per cent fat.	High'st per cent fat.	Time of milking.	Hours from previous milking.	Lowest per cent fat.	Time of milking.	Hours from previous milking.	Range of variation.
TESTS WHICH BEGAN MORE THAN 60 DAYS FROM CALVING.—*Continued.*									
165	82	3.20	4.20	noon.	7	2.50	morn.	9	1.70
172	140	3.29	3.75	night.	6	2.60	"	9½	1 15
177	61	2.87	3.75	noon.	8	2.35	night.	7½	1.40
179	89	3.30	3.90	"	7½	2.90	night and morn	6½, 10	1.00
181	74	3.13	3.95	night	7½	2.35	morn.	9	1.60
190	79	3.34	4 40	noon.	7½	2.70	"	9½	1.70
193	63	3.00	4.50	night.	8	2.00	night.	8	2.50
206	69	3.28	3.80	noon.	7	2.80	morn.	9½	1.00
210	65	3.22	4.10	6 a. m.	6	2.50	6 p. m.	6	1.60
Average..		3.23							1.99
Avg. all old cows..		3.17							1.76
Avg. all 1-15 days....		3.20							1.62
Avg. all 16-30 days.		3.24							1.60
Avg. all 31-60 days.		3.06							1.59
Avg. all 61— days.		3.20							1.60
Avg. of all tests.....		3.16							1.60

In arranging the data given in Table III we had in mind four questions: (1) Does the per cent of fat vary as the period of lactation advances. (By "period of lactation" is meant the time intervening between two successive calvings.) (2) Is there a variation in the per cent of fat between animals of different ages. (3) At what time of day are the highest and lowest per cents of fat found, and are they governed by the time of day or by the length of time from the previous milking? (4) What is the range of variation in per cent of fat found in different animals, and is it more at one age than another?

In order to answer the first question, the records were grouped according to age and according to the length of time from calving to the beginning of the test. Four groups were made of each age: I, of those cows whose tests began from one to fifteen days inclusive from the time they dropped their last calf; II, of those whose tests began from 16 to 30 days inclusive from that time;

III, of those whose tests began from 31 to 60 days inclusive; and IV, of those whose tests began more than 60 days from calving. It should be added that of the 47 tests which began more than 60 days from calving, all but 10, or over two-thirds, were 90 days or under.

The averages of each group are given below, together with the general averages of all ages and the average of all cows taken together.

TABLE IV.

AVERAGE PER CENTS OF FAT.

No. of group.		Two-year olds.		Three-year olds.		Four year olds.		Full aged cows.		Average of all.	
		No.	Avg. per cent.	No.	Avg. per cent.	No.	Avg. per cent.	No.	Avg. per cent.	No.	Avg. per cent.
I	Cows tested 1 to 15 days from calving	5	3.12	6	3.52	9	3.30	9	2.94	29	3.20
II	Cows tested 16 to 30 days from calving...........	22	3.15	12	3.30	8	3.07	16	3.38	58	3.24
III	Cows tested 31 to 60 days from calving....... ...	29	3.07	14	3.01	11	3.06	22	3.07	76	3.06
IV	Cows tested more than 60 days from calving......	18	3.15	6	3.24	7	3.22	16	3.23	47	3.20
	Average of all	74	3.12	38	3.22	35	3.13	63	3.17	210	3.16

A glance at this table will show that qnestion 1 is not answered so far as all the cows are concerned. The smaller number tested from one to fifteen days from calving may reduce the importance of the comparison, but in all ages except two-year olds the figures can be considered fairly representative. Two-year olds gave the highest average per cent of fat in groups II and IV, three and four-year olds gave their highest average in group I, and full aged cows in group II. All except full aged cows gave the poorest milk when the test began in group III, and these find their lowest average in group I. With the exception of group III, all of the groups average practically the same for all ages. More cows were tested in group III than in any other group, which may give more weight to the figures of this group; but considering the data at hand there does not appear to be any

decided increase or decrease in the per cent of fat at any time up to ninety days from calving. Beyond this time we can draw no conclusions because less than one-twentieth of all the animals were tested at a longer period from calving.

We find that there is little variation in the average per cents of fat between animals of different ages. Two-year olds average 3.12 per cent, three-year olds 3.22, four-year olds 3.13, full aged cows 3.17, and the average of all ages 3.16.

In order to answer question (3) as to the time of day at which the highest and lowest per cent of fat was found in the milk, we arranged in Table III along side of the highest and lowest per cent of fat found during the seven days, the number of hours which had elapsed between the milking at which such per cent was found and the milking just preceding. These figures may be seen in Table III in the columns marked "Hours from previous milking." Collecting together all those instances where the per cents were highest at morning, noon, and night, with the hours intervening between milkings, we have the following averages:

Time of milking.	No. of instances at which the milk was highest in fat.	Average number of hours from previous milking.
Morning	8	8.37
Noon	117	7.44
Night	74	6.59
Total and average	199	7.16

Collecting the instances of the lowest per cents of fat in the same manner, we have the following averages:

Time of milking.	No. of instances at which the milk was lowest in fat.	Average number of hours from previous milking.
Morning	165	9.47
Noon	12	7.79
Night	25	7.72
Total and average	202	9.16

In the morning the average number of hours preceding the lowest per cents of fat exceeds the number of hours preceding the highest per cents of fat by 1.1 hours. In like manner at noon the excess of hours following lowest per cents of fat over those following highest per cents of fat is .35, and at night the

excess is 1.13 hours. The general averages of all the hours in each case gives an average of 7.16 hours between milkings where the highest per cents of fat were found and 9.16 where the lowest per cents of fat were found, or a difference of two hours. Accordingly, we may say that, as a rule, the highest per cent of fat follows the shortest period between milkings, and the lowest per cent of fat follows the longest period between milkings. However, looking only at the table of highest per cents of fat we see that the greatest number of highest per cents comes at noon, notwithstanding the fact that the average period from morning to noon is nearly an hour longer than the average period from noon to night. In the table of lowest per cents of fat it is to be observed that the lowest per cent occurs only one-half as many times at noon as at night, although the number of hours from each previous milking averages practically the same. Taking all these fact into consideration, it would seem that there is a tendency for the milk to average higher in fat at the noon hour than at any other time of day.

An interesting study bearing on this point is found in Table V. Twenty-two of the cows, while on test, were milked as nearly as possible at exactly equal intervals, eight at intervals of eight hours each and fourteen at intervals of six hours each, or four times daily. This table is arranged in two main divisions, one for highest per cents of fat and one for lowest, and under each division is given the time of day at which the milking was done. Then in the appropriate column, opposite each cow's number, is given the number of times during the week that she reached the highest and lowest daily per cent of fat.

TABLE V.

RICHEST AND POOREST MILK WHEN COWS WERE MILKED AT EQUAL INTERVALS.

Number in Tables I, II and III.	Highest per cent of fat. Time of milking.				Lowest per cent of fat. Time of milking.			
	5 a. m.	1 p. m.	9 p. m.		5 a. m.	1 p. m.	9 p. m.	
67	3	4	1		3	2	3	
68	2	3	1		4		2	
138		6	2		4	1	2	
139	1	4	2		3		3	
140		6			2		6	
143		6			6		1	
200		3	4		7	1		
204	1	6	2		4		3	
Total.....	7	38	12		33	4	20	
	6 a. m.	12 m.	6 p. m.	12 md.	6 a. m.	12 m.	6 p. m.	12 md.
44	2	1	3	4	3	2	2	
112	2	3	1	1		1	4	2
133		4	4		5			2
187	1	2	2	3	5	2	1	1
210	2	3		1			3	3
Total.....	7	13	10	9	13	5	10	8
	4 a. m.	10 a. m.	4 p. m.	10 p. m.	4 a. m.	10 a. m.	4 p. m.	10 p. m.
60		5		1	2	1	2	1
61	1	4		2	2		3	2
100	2	1	1	3	3	2	3	
101		3		4	3		3	
102		4	2		4			3
144	1	5					6	
201	2	3		1	2		2	3
202		5		1	3		3	2
203		3	3	2	4		1	1
Total.....	6	33	6	14	23	3	23	12
Total of all which were milked four times daily	13	46	16	23	36	8	33	20

Among the eight cows which were milked at three equal intervals it will be seen that, of all the instances where the milk reached its highest daily per cent of fat, 38, or two-thirds, came at

the middle of the day, whi e of the 57 instances of lowest daily per cent, 33, or over one-half, came at the morning milking.

In considering those cows which were milked four times daily, it will be practically correct to count the four and six o'clock milkings together, and the other milkings in the same order as arranged in the table. Then for the complete summary we have 98 instances where the milk reached its highest daily per cent of fat, of which 46, or nearly one-half, occur at the noon hour, and twice as many as at any other time. In the lowest per cents of fat there is very little difference between the number of instances at morning and afternoon milkings.

These figures then, bear out the statement made above, that the milk drawn at noon has a tendency to average higher in per cent of fat than the milk drawn at other times during the day, and this seems to be true whether the milking be at equal or unequal intervals. The lo st per cents of fat, however, do not so invariably occur at ne morning milkings as when the cows are milked at unequa intervals with the longest period invariably between night and morning. When the milkings are at equal intervals the honors are divided between morning and night, especially if there be four milkings daily. It would be of interest to know the causes of all these variations, but at present we are more or less in the dark in regard to them. May it not be that the higher per cent of fat at noon is partly the result of the warmer and more even temperature surrounding the animal?

As to the range of variation in the per cent of fat during the week found in different animals, the following summary from Table III will give some indication.

Age.	Greatest Variation.	Least Variation.	Average Variation
Two-year olds	3.60	.40	1.42
Three-year olds	3.20	.60	1.48
Four-year olds	3.00	.75	1.76
Full-aged cows	4.10	.70	1.76
Average of all cows			1.60

The greatest average variation is found among those animals which we would naturally suppose to be most constant in their per cent of fat, namely, the older cows. The average variation for four-year olds and full-aged cows is exactly the same. The

average variation for two and three-year olds is practically the same, and about three-tenths of one per cent lower than among the older cows.

If the variation in per cent of fat be averaged according to the groups given in Table IV, a striking similarity is found between the averages for the different groups as can be seen from the figures here given.

No. of Group.		Average Variation.
I.	Cows tested 1 to 15 days from calving	1.62
II.	" " 16 to 30 " " "	1.60
III.	" " 31 to 60 " " "	1.59
IV.	" " more than 60 days from calving	1.60
	Average of all	1.60

In the table below are given two instances under each age of individual variation in per cent of fat,—one for the greatest and one for the least variation. Along side of the greatest variation for the week is given the greatest variation for one day and also the pounds of milk and per cent of fat for each milking on that day, together with the total fat for the day. There is also given the same data for the day on which the least variation in the per cent of fat occurred, and finally the total fat for the week. Moreover, in order to compare these animals showing so great and so little variation with animals of the same class, there is also given under each age the largest, smallest and average weekly yield of fat for that age.

TABLE VI.—INDIVIDUAL VARIATION IN PER CENT OF FAT.

Number in Table I.	Age.	Greatest and least variation in per cent of fat.		Pounds of milk and per cents of fat given at the three milkings on that day.						Total pounds of fat.	
				Morning.		Noon.		Night.			
		For the we'k	For one day.	Milk.	Fat.	Milk.	Fat.	Milk.	Fat.	For the day.	For the week.
70	2	3.60	3.40	14.625	2.0	15.250	5.4	12.000	3.6	1.549	
			.10	13.000	2.4	14.000	2.5	16.625	2.4	1.061	9.695
14	2	.40	.30	17.625	3.1	12.000	2.9	13.250	2.8	1.265	
			.10	16.000	3.0	12.375	2.95	12.125	2.9	1.197	8.289
	Largest weekly yield of fat for two-year olds										12.675
	Smallest " " " "										5.263
	Average " " " "										8.697
99	3	3.20	3.20	19.000	2.0	18.500	4.0	15.500	5.2	1.926	
			1.10	20.688	3.1	18.125	4.2	15.375	3.8	1.986	12.978
106	3	.60	.40	18.938	2.9	14.250	3.3	16.375	3.1	1.527	
			.10	19.000	3.3	14.125	3.3	16.125	3.2	1.609	10.824
	Largest weekly yield of fat for three-year olds										17.472
	Smallest " " " "										7.665
	Average " " " "										11.555
145	4	3.00	2.50	19.500	2.2	17.250	4.7	17.000	3.5	1.835	
			.10	18.375	3.5	15.750	3.5	16.625	3.4	1.759	13.069
122	4	.75	.50	21.375	2.65	22.000	2.65	19.750	3.15	1.771	
			.20	21.688	2.95	21.188	3.00	22.313	2.80	1.901	12.713
	Largest weekly yield of fat four-year olds										18.265
	Smallest " " " "										7.100
	Average " " " "										13.091
155	6	4.10	2.95	10.688	2.15	14.188	5.10	5.000	.60	.184	
			1.65	16.125	2.80	14.063	4.45	5.563	4.25	1.314	8.761
192	11	.70	.60	24.875	3.10	20.000	3.50	21.000	3.70	2.248	
			.20	24.750	3.40	20.500	3.50	21.000	3.30	2.253	15.459
	Largest weekly yield of fat for full aged cows										21.333
	Smallest " " " "										8.761
	Average " " " "										14.106

Here it will be noticed that among the examples of largest variation each animal, except the full aged cow, No. 155, gave more fat than the average for her class. Those with the least variation are only a little lower than the average in total fat except the full aged cow, No. 192, which is quite above the average. Thus it is evident that neither those animals which vary much in per cent of fat nor those which vary little can be ter ned abnormal animals, and that a cow can give a good yield of fat if her per cent does or does not fluctuate widely.

TABLE VII.

RECORDS OF COWS WHICH HAVE BEEN TESTED MORE THAN ONCE.

Name of Cows.	No. in tables I and II.	Age at calving. yr.mo.da	Days from calving.	Pounds of milk.	Average per cent fat.	Pounds of fat	per cent of gain or loss.	Per ct. incr'se required on equivalent record.
Inka Pietertje Mechthilde	2	2– 0–27	36	282.250	3.08	8.696		
	78	2–11–23	11	349.125	3.25	11.348	+30.5	19.8
	199	5–10 29	35	409.938	3.08	12.614	+11.2	36.9
DeKol 2d's Pauline	4	2– 0– 4	63	245.000	3.72	9.116		
	80	3– 1–26	12	338.250	3.45	11.676	+28.1	25.3
Sadie Vale Concordia	8	1–11–25	28	317.625	3.50	11.116		
	11	1–11–25	53	295.250	3.30	9.756		
	82	3– 3–29	56	414.500	3.50	14.485	+30.3	30.5
	134	4– 6– 3	13	494.250	3.66	18.103	+24.9	20.1
	*201	5– 5– 3	18	542.313	3.09	16.772		
America 2d's Pauline Paul	9	1–11–26	24	247.000	2.80	6.906		
	10	1–11–26	49	236.438	2.87	6.780	— 1.8	
Clothilde Artis Belle	18	2– 0–29	61	273.750	3.40	9.372		
	133	4– 1–10	14	466.750	3.05	14.272	+54.4	44.3
Pauline Paul Grant	20	2– 1– 4	68	354.188	2.96	10.487		
	86	3– 7– 4	47	417.500	2.90	12.116	+15.5	32.6
Princess of Wayne 7th's Pauline	22	2– 1–11	22	242.500	3.75	9.082		
	85	3– 4– 8	18	327.000	3.61	11.824	+30.2	26.9
Princess Aaggie's Pauline DeKol	23	2– 0–29	21	243.125	3.24	7.879		
	87	3– 2–22	51	343.000	3.02	10.378	+31.7	25.0
	142	4– 2–24	24	478.375	3.02	14.461	+39.2	17.4
Prairie Flower's Pauline Paul 2d	25	1–10– 8	20	321.500	3.17	10.184		
	92	3– 4–21	45	310.625	2.85	8.846	—13.1	34.1
Mutual Friend's Pauline DeKol	26	2– 1–22	51	239.625	3.56	8.538		
	93	3– 8–12	68	344.125	3.43	11.816	+37.2	34.8
Pauline Paul America 2d	27	2– 1–13	57	263.250	3.37	8.860		
	94	3– 8–24	55	345.500	3.18	11.094	+25.2	34.9
Inka 8th	29	1–11– 7	47	242.500	3.15	7.649		
	145	4– 0– 3	21	383.500	3.40	13.069	+70.9	46.0
Clothilde Artis Topsy	37	1–11–24	86	298.250	3.01	8.970		
	88	3– 1– 8	30	441.250	3.21	14.176	+58.0	24.9
	*146	4– 1–10	37	415.750	3.29	13.724		

*Economic food test.

Name of cow.	No. in tables I and II.	Ages at calving. yr.mo.da	Days from calving.	Pounds of milk.	Average per cent fat.	Pounds of fat.	Per cent of gain or loss.	Per ct. incr'se required on equivalent record.
America 2d's Pauline DeKol	38	2- 1-29	21	334.375	2.79	9.339		
	*39	2- 1-29	105	305.188	3.32	10.043	+ 7.5	
	101	3- 5-15	27	520.188	3.06	15.903	+58.3	27.7
Paul DeKol's Mutual Friend	40	2- 0-15	72	242.125	3.50	8.500		
	100	3- 3-29	27	375.938	3.18	11.955	+40.6	28.3
Patty Waldorf	43	2- 1-22	90	244.000	3.12	7.616		
	98	3- 3-18	17	364.188	2.97	10.810	+41.9	24.9
Clothilde Artis Aaggie Bright	47	2- 0-23	34	256.813	3.47	8.896		
	105	3- 1-22	14	325.313	3.96	12.875	+44.7	23.6
Clothilde Artis Aaggie Lass	48	2- 0-21	26	258.188	3.21	8.298		
	106	3- 1- 1	25	339.313	3.19	10.824	+30.4	22.5
Clothilde Artis Constance	49	2- 0- 3	46	275.875	3.05	8.424		
	107	3- 0-20	38	367.188	3.11	11.423	+35.6	23.2
Clothilde Lunde Artis	50	2- 0- 7	15	281.750	3.34	9.404		
	108	2-10-28	64	371.625	3.45	12.821	+36.3	19.7
Hetje 6th's Pietertje	51	2- 2-10	6	251.750	3.48	8.783		
	103	3- 0-29	41	384.313	2.89	11.123	+26.6	18.8
AaggieGrace Clothilde	55	2- 0- 9	107	280.438	3.17	8.890		
	109	3- 3-16	20	462.375	3.20	14.796	+66.5	28.2
Mutual Friend 3d	76	3- 2-24	17	409 188	4.27	17.472		
	77	3- 2-24	42	355.438	3.59	12.738	—27.1	
	121	4- 3- 8	15	427.938	4.27	18.265	+ 4.5	18.1
	184	5- 6-15	25	431.938	3.83	16.327	—10.6	10.7
	*190	5- 6-15	79	363.875	3.34	12.184		
	*202	6- 6-26	44	427.438	3.44	14.724		
Pauline Paul Georgie	79	3- 4-20	15	344.875	3.30	11 406		
	128	4- 4-15	37	437.625	3.16	13.808	+21.1	16.7
	188	5- 3-20	30	376.125	3.40	12.819	— 7.2	13.1
Helena Burke	115	4- 3-10	57	418.000	3.21	13.416		
	162	5- 3- 0	9	518.250	2.91	15.089	+22.5	10.6
	187	7- 3-10	31	654.125	3.11	20.364	+51.8	10.6
Magadora	119	4- 1- 6	31	353.625	3.00	10.696		
	173	5- 1-20	11	444.500	2.84	12.605	+17.8	11.1
Debora's Inka	125	4- 5- 0	61	521.250	2.91	15.188		
	194	5- 5-23	24	509.000	3.08	15.667	+ 3.2	8.4

*Economic food test.

Name of cow.	No. in tables I and II.	Age at calving. yr.mo.da	Days from calving.	Pounds of milk.	Average per cent fat.	Pounds of fat.	Per cent of gain or loss.	Per ct. incr'se requir-ed on equiv-alent record.
Princess of Wayne 7th	129	4- 3-20	40	459.625	2.93	13.450		
	189	5- 2-29	30	463.625	3.16	14.680	+ 9.1	10.2
	203	6- 1-27	38	491.438	3.17	15.600	+15.9	10.2
Hartog Pieterje Netherland	132	4-10-13	62	415.688	3.86	16.258		
	*135	4-10-13	96	403.750	3.44	13.819		
Netherland Hengerveld	151	5-10- 3	65	410.250	3.32	13.627		
	174	7-11- 7	23	544.875	3.92	21.333	+56.5	
Inka Hartog	152	7- 1-16	3	383.125	2.83	10.960		
	164	8- 0-16	35	494.125	2.95	14.573	+33.0	
Netherland Wayne	159	5-10-16	59	436.000	2.93	12.767		
	166	6-11- 4	53	446.438	2.79	12.470	— 2.3	
Mutual Friend 2d	160	7- 0-17	22	585.125	3.52	20.608		
	182	9- 1- 3	18	589.250	3.44	20.242	— 1.8	
Plum 4th	161	6- 0- 5	20	419.000	3.70	15.519		
	165	6- 0- 5	82	465.250	3.20	14.837	— 4.4	
Aaggie 3d's Wayne	163	7- 4- 5	21	487.063	3.22	15.705		
	171	8- 3- 5	17	497.063	3.34	16.582	+ 5.6	
	*183	9- 2-12	8	410.000	3.64	14.773		
Aaggie Grace 2d's Pietertje	177	5- 2- 0	61	624.938	2.87	17.906		
	197	6- 2-23	34	651.750	2.89	18.803	+ 5.0	
Patty's Pet	179	9-11-13	89	380.125	3.30	12.562		
	185	11-0- 2	22	453.500	3.57	16.203	+28.9	
	*192	11-0- 2	56	460.875	3.35	15.459		
Sadie Vale 2d	181	7- 2-25	74	322.813	3.13	10.099		
	198	8- 3-14	27	340.250	3.40	11.656	+15.4	
Janie Hijlaard's Inka	186	5- 0-26	30	446.063	3.43	15.320		
	193	5- 0 26	63	451.125	3.00	13.536	—11.6	
Aaggie Grace's Boy's Topsy	191	7- 0-17	39	448.375	2.99	13.410		
	207	8- 0-13	54	458.250	3.01	13.800	+ 2.9	
Vrouwkje of Hijlaard 7th	195	6- 1- 4	38	441.625	3.04	13.427		
	205	7- 0-26	39	492.250	3.00	14.791	+10.1	
Average of 2 to 3 year olds							+34.4	26.4
Average of 3 to 4 year olds							+21.7	19.0
Average of 4 to 5 year olds							+12.0	11.3
Average of all cows exclusive of those which were tested twice in the same period of lactation or not tested until they had reached full age							+26.6	21.4

*Economic food test.

Table VII places in ready comparison the records of those cows which have been tested more than once. Nine were tested twice during the same period of lactation and all of these gave a less amount of fat on the second test than on the first except No. 39. In this case she gave less milk than at the first test, but her per cent of fat was greater by .53 of 1 per cent, so that the total fat was also greater. (She was in an "Economic Food Test" the second time.) Three gave more milk and two a higher per cent of fat on the second test than on the first. The average production of the nine on their first tests is,—386.042 pounds of milk, 3.53 per cent fat and 13.829 pounds of fat. Their average on the second tests is,—381.91 pounds of milk, 3.27 per cent fat and 12.128 pounds of fat. Accordingly, we may infer that, as a rule, a cow which has been forced to her utmost for seven days cannot again be made to reach the same point either in production of milk or fat during the same period of lactation.

"EQUIVALENT RECORDS."

According to the scheme adopted by the Holstein–Friesian Association for the admission of cattle into the Advanced Registry, each two-year old must have produced 7.2 pounds of fat, three-year old 8.8, four-year old 10.4, and each cow, five years old or older, 12 pounds of butter-fat in seven days. It is considered by the Association that a two-year old which produced 7.2 pounds, a three-year old which produced 8.8 pounds, or a four-year old which produced 10.4 pounds of fat would, when she reached the age of five or over, produce 12 pounds. Or, in other words, a yield of 7.2 pounds of fat by a two-year old, 8.8 by a three-year old, or 10.4 by a four-year old is equivalent to 12 pounds when the heifer reaches full age. To make this plan good there must be a gain of 1.6 pounds of fat during each succeeding year, which requires an average gain of .13⅓ pounds per month and .00438 pounds per day. In other words, the gain from two to three years must be 22.2 per cent, from three to four years 18.2 per cent, and from four to five years, 15.4 per cent.

In Table VII in the column headed "Per cent of Gain or Loss" is given the actual gain or loss per cent sustained by the cow from one test to another. In the column headed "Per cent of

Increase required on Equivalent Record " is given the per cent of increase the cow ought to make for the same length of time in order to make good her equivalent record. For the basis of determining what the per cent of gain on the equivalent record should be, there is taken the amount of fat the cow should produce during the time which elapsed between two successive calvings; this amount is divided by the amount of fat a cow of her age should produce at the time of the first of these two calvings; for example, No. 2 was 2 years and 27 days old at the time she dropped her first calf, and at such age should produce 7.318 pounds of fat. The time intervening between the first and second calf was ten months and 26 days, and she should gain in this time in production of fat 1.447 pounds. This would make a gain over 7.318 pounds of 19.8 per cent, which is her required gain on the basis of equivalent records. Her actual gain was 30.5 per cent, so that she did much better than her requirement. On the other hand, this same cow from the ages of three to five actually gained 11.2 while her required gain was 36.9 per cent. In working out equivalent records no account is taken of age over five years.

In the same manner the actual and equivalent gains are made out for those cows in Table VII which were tested at the various ages from two to five and the averages under each head and for each age are given. From these averages it will be seen that among the different ages, three, four and five-year olds, the actual gains were in excess of the gains required on the basis of equivalent records.

The actual gains from year to year as determined from the average records of all the cows, and the average gains required on equivalent records present such a wide variation from each other and from the figures determined in Table VII, that we have placed all the averages in tabular form below for ready comparison.

	From 2 to 3 years. Per cent.	From 3 to 4 years. Per cent.	From 4 to 5 years. Per cent.
Actual gain as found from average product for all cows of different ages (Table I)	32.7	13.3	7.7
Average gain required on equivalent record plan	22.2	18.2	15.4
Actual gain as found from average gains of cows that were tested more than once	34.4	21.7	12.0

From the averages found in Table I it would seem that, as a rule, the cow has nearly reached her full capacity for production at the age of four years and that she does not gain as much in the remaining year as is required by the equivalent record system. On the other hand, a study of the cases given in Table VII shows this system to be fairly accurate. It is without question that the cows which have been tested several times are above the average in power of production and for this reason they may be more able to keep up the pace set for them than are the average cows.

GENERAL SUMMARY AND CONCLUSIONS.

The largest total yield of fat among two, three, four-year old, or full aged cows, is, under every age, accompanied by the highest per cent of fat found among cows of that age.

The smallest yield of fat for each age of animal is accompanied in only one case by the lowest per cent of fat, and that among the two-year olds.

The largest yields of milk do not contain the lowest per cents of fat nor do the smallest yields of milk contain the highest per cents of fat.

The stall fed cows average higher in total yield of milk and fat and in per cent of fat than the cows at pasture.

Equal quantities of the same kinds of food or similar quantities of different kinds of food produce widely varying amounts of milk and butter in different animals.

To produce the same or similar amounts of milk and butter different animals require widely varying amounts of food.

Cows, although of the same breed and raised in the same herd, vary greatly in their power to make an economic use of food.

The cost of production is greatest among two-year olds and decreases gradually as the age increases up to four years, after which there is little if any variation.

Within a period of ninety days from calving there is but little average variation in the per cent of fat among the different ages, except that the average of all the tests made at thirty-one to sixty days from calving is lower than for any other period.

There is slight variation in the average per cent of fat between two, three and four-year olds, and full aged cows.

The highest per cents of fat usually follow the shortest period between milkings. The lowest per cents of fat usually follow the longest period between milkings. Where the cows are milked at equal intervals the highest per cent occurs most often at or near the noon hour, and the lowest per cent about equally often at morning and night with a much larger number at midnight than at noon.

The average range of variation during seven days between the highest and lowest per cents of fat for individnal animals is greater among four-year olds and full aged cows than among the younger animals.

Neither the cows which show very great variation during seven days in the per cent of fat nor those which show slight variation are abnormal animals, since their total product of milk and fat is near the average for their class.

Cows which have been once tested and forced to their greatest capacity for a week rarely reach the same height of production again during the same period of lactation, even though the circumstances be otherwise most favorable, but frequently have made increased records in succeeding periods of lactation.

There is an increase of only 7.5 per cent of milk and 7.7 per cent in fat of full aged cows over four-year olds, which shows that, on an average, cows have very nearly reached their largest production between the ages of four and five.

The "Equivalent Record" plan is supported by the records of individual cows which have been tested at various times from two to five years of age, but not by the average records of all the cows of the different ages.

The Following Bulletins are Available for Distribution to Those Who may Desire Them.

39 Creaming and Aerating Milk, 20 pp,
40 Removing Tassels from Corn, 9 pp.
41 Steam and Hot-Water for Heating Greenhouses. 26 pages.
49 Sundry Investigations of 1892, 56 pp.
53 Œdema of the Tomato, 34 pp.
55 Greenhouse Notes, 31 pp.
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139. Third Report upon Japanese Plums.
140. Second Report on Potato Culture.
141. Powdered Soap as a Cause of Death Among Swill-Fed Hogs.
142. The Codling-Moth.
143. Sugar Beet Investigations.
144. Suggestions on Spraying and on the San José Scale.
145. Some Important Pear Diseases.
146. Fourth Report of Progress on Extension Work.
147. Fourth Report upon Chrysanthemums.
148. The Quince Curculio.
149. Some Spraying Mixtures.

Bulletins Issued Since the Close of the Fiscal Year, June 30, 1898.

150. Tuberculosis in Cattle and its Control.
151. Gravity or Dilution Separators.
152. Studies in Milk Secretion.

Bulletin 153. October, 1898.

Cornell University Agricultural Experiment Station,

ITHACA, N. Y.

HORTICULTURAL DIVISION.

IMPRESSIONS OF OUR
FRUIT-GROWING INDUSTRIES

By L. H. BAILEY.

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CORNELL UNIVERSITY, ITHACA, N. Y., Oct. 21st, 1898.

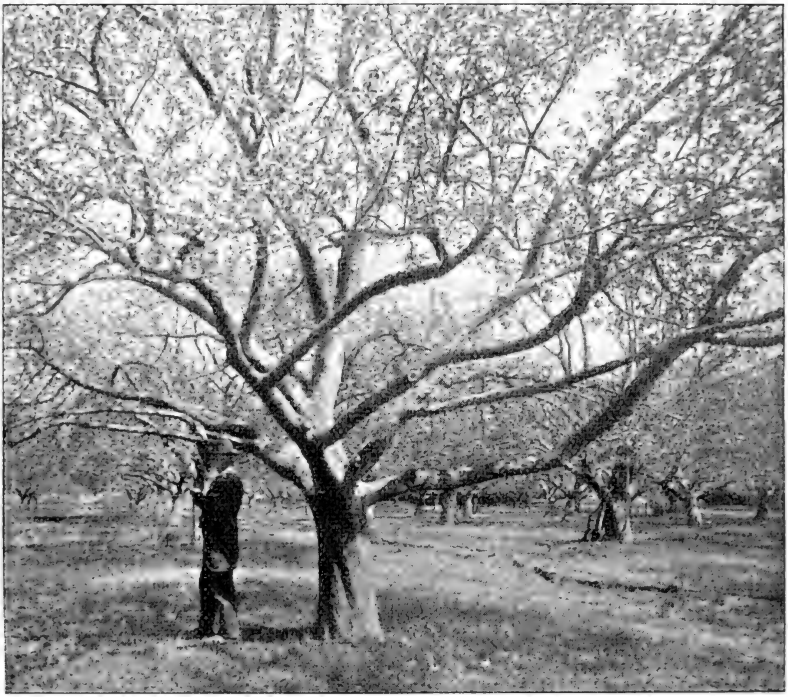
THE HONORABLE COMMISSIONER OF AGRICULTURE,
ALBANY, N. Y.

Sir: This bulletin is submitted for publication under Chapter 67 of the Laws of 1898.

Five years ago Professor L. H. Bailey began to make a careful study of the fruit-growing industry. Since that time he has visited Florida and other southern states and has made himself familiar with the production of many classes of fruits. He has studied the problems under consideration not only in all of the fruit-growing counties of this state, but has made trips into the fruit-growing districts of Europe.

While this bulletin does not embody the results of strictly scientific investigations, it does give, in a concise form, the conclusions reached by the author after a long, careful study of fruit-growing under widely different climates, soils, markets and local conditions. Few Americans have had the opportunity for making such extended observations and few writers on fruit-growing have shown a greater interest in the welfare of both producer and consumer. It is therefore with pleasure that I submit this bulletin which embodies the ripened judgment of an expert.

I. P. ROBERTS,
Director.



7.—*Clean tillage in a New York orchard. It is commonly said that plantations in which the trees are trained so low cannot be well tilled. For a discussion of means of tilling orchards, see our Bulletin 72.*

IMPRESSIONS OF OUR FRUIT-GROWING INDUSTRIES.

Some years ago, the writer was asked to undertake an investigation, on behalf of the State, of the fruit-growing of New York. An attempt was made to determine the extent and condition of the industry, to discover the leading difficulties, to devise means to combat insects and fungi, and, by means of lectures and publications, to give advice to fruit-growers. As a result of the inquiries, there have appeared, by various persons, 34 bulletins, covering most of the fruits which are commercially grown in the State. In the progress of these investigations, it became apparent that there are greater problems in our fruit-growing than those of soil and insects and diseases, that fruit-growing is profitable or not, in the long run, in proportion as it meets the general requirements of trade and conforms to the agricultural status of the time. It became apparent, also, that even the immediate problems of fertilizers, tillage, and handling of a plantation cannot be fully understood from mere scientific investigations at a given place. The investigator must correlate and compare the results of actual fruit-growing in many places and under many conditions to be sure that he arrives at broad and sound conclusions, or at principles. With this thought in mind, an effort has been made, in the last five years, to determine the underlying reasons for some of the successes and failures of the fruit-grower, by studying the actual experiences of fruit-raisers; and some of the summary conclusions of this inquiry are given herewith. Such conclusions are necessarily colored by the personality of an author, and the writer must therefore say that they are meant to be expressions of general truths rather than statements of specific facts, and that he cares less whether they are accepted by the reader than that they shall suggest his thinking out his problems for himself.

I. America is a Land of Fruits.

The fruit-growing interests of the United States are very large and are rapidly expanding. Of some fruits we are already raising more than we consume, and we therefore find a market abroad; and if we are to compete in foreign markets, we should know something of the conditions under which the fruits of our competitors are grown. In other words, it is important that we understand why America is a land of fruits.

1. America is a land of fruits because, for one thing, its agriculture is so recent and so little bound by tradition, that the farmer feels himself free to discard old and unprofitable enterprises for new and relatively profitable ones.

In the unrest which has come from agricultural depression, the newer and less-worked business of fruit-growing asserts itself over the old-time agriculture. It does not follow, however, that fruit-growing will continue to be the more lucrative business. In fact, it is possible that it may come to be overcrowded. But its rise has relieved the over-worked old-line farming, and, as a whole, has been a blessing both to those who went into it and to those who remained out of it; and it has exerted a most important secondary influence in diffusing new knowledge and thereby in educating the people.

2. Again, North America is the leading fruit-growing country of the world because large areas are available for the business.

Fruits are grown on a large base, and in wholesale quantities. This means that they are grown cheaply and that the product is of sufficient quantity and uniformity to attract the attention of the market. This is illustrated in a smaller way by comparing the two sides of the continent: Californian fruit is often able to drive the eastern fruits from their own markets because it is in larger and more uniform supply and thereby controls the market. It is the large base upon which American fruit-growing is established which enables it to enter European markets.

3. Political and social conditions are essentially uniform in all parts of the country, allowing of a free interchange and comparison of ideals and methods.

In Europe, the various fruit-growing centers are apt to be unique. The business is the outgrowth of years and centuries of local effort and tradition. There are difficulties or barriers of races, languages, political systems, and physiographies. Uniformity of methods and results on a large base is practically impossible. In North America, we speak one language and live in practically one political and social environment. We can therefore have community of ideals. We grow thousands of acres of one variety, if need be, and growers work towards a common end.

4. The climate of North America is congenial to fruits.

5. The American farmer has more help from teachers and experimenters than other farmers have.

A fundamental idea of our agricultural colleges and experiment stations is to reach the very man who tills the soil. The teacher and the farmer are in most intimate contact. As a consequence, the fruit-grower quickly assimilates new methods. He is not fettered by tradition. He is bold and confident. He feels that he controls his own efforts and destinies. He receives help at every doubtful point. The result of all this is that the general tone of agricultural business is rising, and the farmer is feeling more and more independent because he knows that he can receive aid and advice in his perplexities. Even those persons who depreciate the colleges and stations, are nevertheless greatly dependent upon them, for they share the general mental uplift and partake of the new ideas which diffuse from the teacher and the experimenter into every farmer's meeting, into the schools, and the rural press. Public sentiment is compelling better farming.

As a consequence, knowledge of all theories and practices which make for better fruit-growing are being rapidly popularized. It is enough to cite only a single example,—the fact that spraying for the control of insects and diseases is better understood and more extensively practiced by the fruit-growers of America than by those of any other country.

II. Problems of Marketing must Receive Greater Attention.

It is generally the first thought of the fruit-grower to plant that kind of fruit which he can raise. It is quite as important, however, to plant that which he can sell. It is the business of the experiment station to determine means of increasing the production; it does not teach means of selling the product except as it makes the product better. There is necessity, therefore, that problems of marketing receive more and more attention from farmers; and these problems are more complex with the increase of population and of competition.

The first step in a discussion of marketing is a classification of the purposes of the given enterprise. Classified in respect to the objects in view, there are two kinds of fruit-growing,—that which desires the product primarily for home use, and that which desires it primarily for market. Of market or commercial fruit-growing, there are again two types,—that which aims at a special or personal market, and that which aims at the general or open market. The ideals in these two types of fruit-growing are very unlike, and the methods and the varieties which succeed for the one may not succeed for the other.

The man who grows fruits for the special market, has a definite problem. The product is desired for its intrinsic qualities; and special products demand special prices. The man who grows fruit for the world's market, has no personal customer. The product is desired for its extrinsic or market qualities; and the world's products bring the world's prices. The special-market fruit-grower generally works on a small base. The world's-market fruit-grower works on a large base; or he sells to another who, by combining similar products of many persons, is able to command the attention of the market. Failure to distinguish these two categories is the result of a confusion of ideas. One grows fruit either for a special and personal market, in which case he looks for his own customer and is independent of general trade; or he grows what the market demands, and allows the machinery of trade to handle the product. In the latter effort,

the American fruit-grower is preëminent; but in the former he has made little more than a beginning.

1. The essence of these remarks is the fact that in the staple or large-area crops, the demand regulates the supply; whereas, in products which are essentially luxuries, amenities and accessories, the supply largely regulates the demand.

The world's staples are breadstuffs, meats and materials for clothing and building; but in fruits there are some types or varieties which are staples for that group,—staples in the sense that they are adapted to cultivation over wide areas and to be sold in the general and open markets. In apples, the Baldwin and Ben Davis are staples; Chenango and Lady are accessories.

2. It follows, then, that general or staple products find their best outlet in the general and open markets; special and accessory products find their only outlet in particular and personal markets.

This law is well illustrated in the market for glass-house products. Persons are always wondering that there should be sale for forced tomatoes and strawberries after the southern-grown products are in the market; but the fact is that one does not compete with the other. The accident that the products from the glass-house and from Florida are called by the same name does not signify that they are purchased by the same parties. There is a market for glass-house produce and a market for field-grown produce; if the glass-house produce is offered in the other market, the prices are not sufficient to pay the cost. Shall I grow apples on free stocks or on dwarfs? Whichever you like; but with the dwarf-grown fruit you cannot compete in the open market. You cannot afford to sell dwarf-grown apples in barrels: such apples cost too much to raise. You cannot afford to grow Baldwin or Ben Davis on dwarfs, for apples thus grown cannot compete with large-tree orchards; and the gain in quality (due to the better care) of such low-quality varieties when grown on dwarfs, costs more than it is worth. The dessert apples can be profitably grown, perhaps, on dwarfs, provided they are put into a dessert market. The staples may be sold to the itinerent buyer, but the special products must be handled by the producer or his

agent. How often we grow the fruit, but miss the market!

These facts respecting the two classes of products and markets are, it seems to me, the most imperative lessons for the American fruit-grower now to learn.

3. The foreign market may be expected to increase.

I have already outlined the reasons, as they appeal to me, for the great development of fruit-growing in North America; and therein are stated reasons why we can enter the European markets. It only remains to add that the European consumers desire our fruit. It is handsome, uniform, and much of it is of excellent quality. It is also well packed; or, rather, that which is not well packed does not reach the discriminating consumer. The English are now well acquainted with our apples, and fruit-buyers on the continent, particularly in Germany, are learning to know them. The foreign market is only fairly opened: it is not yet supplied. Most persons with whom I have talked in Europe believe that the European fruit-growers cannot compete with the American in general-market fruit and they are looking for a growing trade in American produce; and my own opinion is that they cannot compete with us in apples, and probably not even in pears and some other fruits. But as exportation increases the more discriminating the foreign market will become. Greater and greater attention must be given to packing and grading, selection of varieties, and particularly to good tillage, thinning and spraying; for spraying gives a better keeping as well as a sounder fruit.

A person connected with an experiment station is often asked if he would advise the planting of more fruit. The question is one which pertains to business and is therefore not within the purview of the experimenter; and the success of any venture is intimately associated with the personality of its promoter. Yet, one can form some notion as to whether fruit-growing is overdone, or whether there is still opportunity for expansion. Now, every business is overdone in its common levels. There is competition everywhere. The success of a business, therefore, depends more upon the man than upon the business. The first advice, therefore, is to choose the business which one likes best.

Again, one must not expect a financial success every year. There are good and bad years in fruit-growing, as there are in manufacturing or store-keeping. The fruit-grower should go into the business, therefore, as a long-time or more or less permanent undertaking, expecting to become more adept each year. He should then distinguish the type of market for which he desires to grow. If he is to compete in the general open markets he must work on a comparatively large base. The man who has only a small area will generally do best in the growing of special things—if he have sufficient skill—for personal markets. As a people, we are not diverse enough in our fruit-growing. Too many of us are aiming at the general, common market,—assuming that we aim at all. It seems to me that the success in the general metropolitan and export markets is to be more and more secured by large-area fruit-farming, and that other fruit-farmers must develop sufficient skill to raise choicer things for more restricted and better markets. As a whole, fruit-growing is not overdone, particularly if the foreign markets are properly encouraged and supplied ; but in particular places and cases it is overdone. Some fruits are not capable of indefinite extension. It seems, for example, that grape-growing in western New York has reached the limit of its profitable development for the time being. Grapes are a dessert fruit. They are not used to a large extent in culinary preparations ; and there are few incidental or secondary products,—that is, they are not dried, canned, made into jellies, and the like, to any extent. Moreover, quality in a grape does not show on the surface as it does on apples or peaches. In apples, there is likely to continue to be demand for export, and the demand for dessert apples is almost wholly unsupplied. In fact, the demand of the world's markets has obscured the importance of the special markets. Of good peaches, pears, apricots and berry fruits there is sufficient supply only in occasional years ; for even when the open market may be full, there are still persons who are asking for a better grade for private use. All these hints are given to indicate the fact that success in fruit-growing is quite as much the hunting out of a market as the raising of the fruit ; and the market problem should be clearly in mind from the moment the plantation is planned.

III. THE HANDLING OF THE PLANTATION.

The details of the handling of the fruit plantation are discussed in many bulletins issued from this and other stations; but there are some general considerations—or ways of looking at certain questions—which it may be profitable to discuss.

Sod or tillage.—This an old question, this controversy whether sod or tillage is better for an orchard. Plantations will be cited to prove either case, which really prove them both. That is, for the orchard which does better in sod, sod is the better. But it cannot be that both are equally good; and if not, then we should discover which is fundamentally better, and the other will thereby be the exception which proves the rule. Now, there have been bulletins and expositions enough to show that liberal tillage is the better condition for the orchard; and the man who cites his plantation as an example of a contrary fact, cites only an isolated case and one which should be explained. He does not cite a principle. It is desirable that horses be shod; yet there are circumstances in which it is better that they be barefoot. I shall not repeat arguments for tillage, but give a few summary conclusions of observations.

European large-area orchards are generally in sod; and this fact is perhaps one reason for the prevalence of sod orchards in America, since European practice becomes known in this country through books and foreign-born farmers. There are various reasons for this condition which, it seems to me, will not apply here. In the first place, the country is moist and there is less necessity for conserving moisture than in America. The drier the country, the better is the tillage, other things being the same. Compare the frequency of sod orchards in New England with their infrequency in California. Again, the higher price of land and the smaller farms, make it necessary to support two crops on the same land,—trees and grass. In parts of Europe which are primarily grazing or dairy regions, the tree fruits are in reality a secondary or catch crop, as, for example, in the cider-producing parts of Normandy. In other parts, cattle are kept indoors most of the summer and are fed newly-cut grass; this grass may be gleaned in orchards. Still again, the large-field plantations

of fruit-trees in Europe are generally of secondary importance to the small-area or garden plantations. In the fruit-gardens, the trees are excellently well trained, fertilized and tilled, and the results are usually good. Yet again, there is less horse-labor and fewer horse-tools in Europe than in this country. And finally, many of the plantations are rented, and the lease-holder has little interest in such long-time investments as fruit-trees.

It is undeniable that excellent results are often secured in sod orchards, but the reasons for these good results must be determined for each case. By examining such cases under a wide range of conditions, however, one may be able to formulate a a few general statements or principles. We may first throw out of our inquiry those cases in which the sod is present merely because the owner has neglected to till. He has not had time to care for the orchard as he cares for the other parts of the farm. In most of these cases, the orchard is a mere incident to a general scheme of grain-farming or dairying. The land is needed for pasturage, and if fruit is obtained it is clear gain. This is a perfectly legitimate practice. The owner has no taste for fruit-growing and does not expect to compete with fruit-growers. He is in other business; and it is doubtful if it would pay him to reduce his grazing area and neglect other affairs by keeping the orchard in a high state of cultivation.

There now remain those cases in which the farmer believes that orchards do better in sod than in clean tillage. My own opinion is, from an examination of hundreds of these instances, that the greater part of such orchards thrive in spite of the sod, not because of it. It is very rare that the farmer has made comparisons of the two methods side by side. If he has made any comparative observations, they have been drawn between his plantation and his neighbor's; but the two are often not comparable, being on different sites, soils, and of different varieties. Because an orchard does well in sod, does not prove that it might not do better in tillage.

There are many instances in which the orchardist has tried tillage and has found it to be unsatisfactory. In the greater number of such cases, the tillage was begun too late in the life of the plantation to yield good results: the habit of the trees had already

been established and the shallow root-systems had been formed.

In another class of cases, the grower is misled by an occasional very heavy crop into the belief that his orchard is successful. It is the habit of sod orchards to over-bear at long intervals, or whenever all congenial natural conditions chance to be in unison. Tilled orchards tend to bear more continuously, but may not bear so heavily in occasional years. If the "bearing year" is ever to be controlled, tillage is the first step towards that end.

In other cases, sod orchards thrive because they have been well manured by the droppings of animals which are pastured in them ; but the good results in these instances are due to fertilizing, not to sod. It does not follow, however, that this is the best way to fertilize orchards, although it has the great merit of expediency.

Sometimes seeding-down is the only practicable means of caring for an orchard, because the land is so hilly or rocky that it cannot be tilled.

There remain other instances in which sod seems to be a decided benefit to an orchard. These are cases in which it seems to be necessary to check growth on lands which are over-rich or which hold so much moisture that some of it can be profitably utilized in the growing of grass. On parts of the Cornell grounds, we think it necessary to seed down about fruit trees, because the land has been made so rich that the trees are over-growing and splitting down with the weight of top ; but the seeding-down will be only a temporary expedient. The danger of too rapid growth is particularly great in peaches and grapes ; it is very small with apple trees.

Everyone knows that sod is not good for strawberries, grapes, potatoes, corn, wheat or raspberries ; the presumption is, therefore, that it is not good for apples or quinces. But apples, quinces and pears are tough, and it is surprising what little harm sod can do them when the land is good !

Fertilizing.—I am convinced that it will not yet pay to add commercial fertilizers to the general run of fruit plantations in New York. The tillage and other treatment are not good enough to warrant the extra expense. That is, the product is not of sufficient value to pay for any extra investment ; and the land and trees are in such poor condition that the mere addition of

fertilizer will be of little avail. But the better the tillage and the better the crops, the more it will pay, as a rule, to add fertilizers: the better a thing is, the more will it pay extra care and treatment. And the heavier an orchard bears in its youth, the greater is the presumption that it will need good care and fertilizing in its old age.

All this means that the best fruit-growers will generally find it profitable to use liberally of fertilizers. What fertilizers to use and how to apply them are subjects which are discussed in bulletins by many authors, and it is not necessary to refer to these details here; but even after reading all the literature, the farmer must experiment with his own land and his own crops to determine just what materials are most profitable for his use. In other words, the advice as to fertilizers is more valuable in teaching a man principles, in suggesting means of experimenting, and in designating the probabilties of any line of action, than in specifying just what fertilizers one shall use. Various studies of the effects of fertilizers on horticultural crops have been made by this station, some of which will be published in due season. Of these, two may be mentioned here:

I. In 1894, an unprofitable apple orchard 25 years old, belonging to S. W. McCullom, Lockport, was examined by an expert, who thought that it needed potash. The orchard had been unproductive and had been in sod for some time. It stands on a rather hard dryish light clay loam, in which there are many small stones. The trees, Baldwin and Greening, are in good shape, and looked better than most apple trees do. Some trees received 10 pounds of nitrate of soda, sown as far as the spread of the limbs. Other trees received 10 pounds of muriate of potash, other 10 pounds of sulfate of potash, and others both muriate and sulfate. The materials were lightly plowed in, and the ground was then harrowed. The fertilizers were applied August 11, 1894. The orchard was plowed again in the fall of 1895, and again in the spring of 1896; and it is yet under tillage. In the season of 1895 no results were seen. In 1896, the nitrate-fertilized trees were remarkably darker colored than the others in foliage, more vigorous, and carried a heavier load of fruit. The difference in

foliage could be detected at a distance of a half mile. In 1897, these trees were still superior to others, but the effects were not so marked as in the previous year. In 1898, all effects were lost, and the trees could not be distinguished from their neighbors. In 1896, the potash trees seemed to show a very slight gain, but no difference could be detected between the different potash treatments. In 1897 no effects were noticed; neither at fruiting time in 1898.

This experience is remarkable in two respects,—in showing how difficult it is to predict results with fertilizers in old orchards, and in the slowness with which the nitrate of soda worked. It was eighteen months before the effects of this dressing were seen; and yet nitrate of soda is soluble and is supposed to pass quickly through the soil. There are two explanations of this tardy action of the nitrate: this length of time may have been required to carry the material down to the roots, or the tree may not have recovered from its accustomed lethargy until the season following its appropriation of the nitrogen. This experience is further valuable in showing that the effect of nitrate lasted but two years.

II. In the orchard of J. J. McGowen, near Ithaca, experiments were begun in 1894 and 1896. The trees were 26 years old when tests were begun, and they had been continuously in sod after the first three years. They had been well top-dressed with stable manure for many years, however, and were in good bearing condition. The varieties are King and Baldwin.

Plot A. Plowed in the fall of 1894 and spring of 1895. At the latter time, sulfate of potash was applied at the rate of 750 lbs. to the acre. Clean tillage followed.

The apples of 1895 were larger, and seven to ten days later than those on untreated trees.

In 1896 the tillage was continued, and on May 14 a heavy dressing was made of muriate of potash.

Early in June, 1896, the foliage on the plot was seen to be unusually dark colored and vigorous. The difference could be seen a half mile. There was also a larger crop, not due to more profuse blossoming of the treated trees, but to less loss at the "June drop." The amount of fruit was about twice as great as on adjacent trees, and the apples were larger, later and lighter colored.

These results at once raised the question whether the potash or the tillage had influenced the trees. Consequently, two other plots were undertaken:

Plot B. Top-dressed in June, 1896, with 750 lbs. muriate potash per acre, and August, 1897, with sulfate potash, 750 lbs. to acre. Remains in sod.

Plot C. Plowed and tilled, from June 1896 to 1898. No fertilizer.

Plot A was continued in tillage, and in August, 1897, sulfate of potash was applied at the rate of 750 lbs. per acre.

In 1896, neither plot B or C showed any results.

In 1897, Plot A still had the darkest and best foliage and gave a slightly better yield than the remainder of the orchard; but the results were not so marked as in 1896. The apples were still larger and later.

In 1898, Plot A was still best, although the differences were very little. The fruit on this plot still ran larger than on others, and the owner thought, as in other years, that it was coarser and less sweet. Plots B and C seemed to show no gain over untreated trees.

Here, then, is an orchard, in good bearing condition, which was benefited by a treatment combining tillage and application of potash. Neither of these factors alone gave results. But the extra vigor and yield were at the expense of high color and early maturity. In the McCullom orchard the extra vigor of foliage, due to the nitrogen, seemed to be an unmixed blessing, although it should be said that the nitrogen-fertilized apples were Greenings, in which loss of color would not show. If there is any lesson to be drawn from these comparisons, it is that sod orchards which have been top-dressed systematically with stable manures may be expected to respond less profitably to remedial treatments than those which have not been so treated; but it does not follow that such orchards may not have given still better results if they had been both manured and tilled from the first. In other words, the better the habitual care of the fruit plantation, the less occasion the grower has to worry about it. These experiments also illustrate how different the problems are in different orchards, and how necessary it is that the farmer attempt

to solve these local problems for himself by means of experiment. It is the custom to say that fruits need potassic fertilizers. This may be true as a general statement; but it does not follow that every plantation needs them.

Why are orchards barren?—This is one of the most difficult to answer of all agricultural questions,—why so many orchards are unproductive year after year. There are many causes of unproductiveness; and it is impossible to make an orchard young again in order that it may be brought up in the way it should go. It is a significant fact, however, that of many hundreds of barren orchards which I have inspected, less than half a dozen had received good tillage and other good care from the outset. In fact, barren orchards—of properly selected varieties—which have been well tilled, fertilized and otherwise well treated, are so rare that it is unnecessary to consider them in this discussion.

The most casual observer will agree that neglect is the common and general cause of barrenness in orchards. Even pigs are an unsatisfactory crop when they are obliged to shift for themselves. But it is the business of the experimenter to determine just which element of neglect is responsible for the failure in any particular case. I believe that the most general causes of barrenness are the following, being stated approximately in the order of their frequency and importance: (1) lack of good tillage, particularly in the first few years of the life of the plantation; (2) lack of humus and fertilizer; (3) uncongenial soils and sites; (4) lack of systematic annual pruning; (5) lack of spraying and of attention to borers and other pests; (6) bad selection of varieties; (7) trees propagated from unfruitful stock.

Seasons vary. Some years are good fruit years: in those years most orchards bear. In fact, they are likely to overbear; the trees are thereby depleted, and a bad year follows: the consequences are "bearing years" and "off years." The longer the conditions are allowed to dictate what the crops shall be, the more difficult it is to bring the plantation into a habit of annual bearing. I suspect that half the mature barren orchards of the State could not be made profitable by any line of treatment. They have had their own way too long. In most cases of barren

orchards, something is fundamentally wrong; and fundamentals can not be changed in a day.

In the nature of the tree there is no reason why it should not bear more or less continuously. On the Cornell grounds is a Stark apple tree which was planted in 1890. It is in rich ground and has had good care. It is as large as most trees are at twelve years. It has borne five consecutive crops. In 1896 it bore two barrels of first-quality graded apples; in 1897 it had nearly as many; in 1898 it bore three barrels.

Varieties.—There is a decided tendency in this country to limit closely the number of varieties of any fruit when setting a plantation. Some of the most successful fruit-growers would limit the varieties of apples, pears or strawberries to three or four. Yet, as a matter of fact, the really good varieties of any fruit are usually numbered by scores, sometimes by hundreds, and valuable novelties are always being introduced. Here, then, is a conflict. If the advice of fruit-growers is to be followed, it would seem that the introduction of novelties is unnecessary; and yet without novelties, progress in varieties is impossible.

It is true that varieties should be few in most plantations, but the reason is that most American fruit-growers are raising fruits for the general or open markets; and in these markets, uniformity of product is almost imperative. But if it is fatal to grow many varieties when the world's markets are in view, it may be equally unsatisfactory to grow very few varieties when special or personal markets are in view.

I believe that the tendency is to go too far in the reduction of varieties. We are reducing fruit-growing to a single ideal and are thereby increasing the competition in that direction. There are varieties for different uses, different soils, and different geographical regions; and a variety which fails in every region but one, may still be worth introducing. It is the commonest mistake to recommend a variety for any region merely because it thrives in some other region. Because the Ben Davis is eminently successful in the mid-continental region, is no reason for supposing that it will be equally good in New York; in fact, it is a presumption against its thriving equally well in New York, for a variety rarely does equally well everywhere. A

fruit-grower in western New York asked me if I would advise him to plant Arkansas apples. I told him no; but I advised him to test them.

A variety which is suited only to the general market, is most profitable in that region in which it thrives best. It is doubtful, for instance, if the New York grower can compete long in Kieffer pears with growers in the middle and southern states; and it is certain that those regions cannot compete with New York in Bartletts and Seckels. Wherever a fruit reaches its highest development, there it should be grown; and local varieties are often best adapted to local and personal markets.

The nurseries grow fruit trees to supply the demand for general-purpose varieties; and as a consequence they tend to reduce varieties and to make them uniform over the whole country. Many of the fine dessert varieties cannot be obtained at nurseries. With the refinement of our horticulture more varieties will be grown. The more fully the horticulture of any country is developed, the more perfectly are the various localities and needs supplied. In this direction we have much to learn from Europe, for one is there impressed with the great numbers of varieties which are actually known and grown. But in Europe, the fruits are grown for local and personal markets; here we grow for the world's markets, and varieties must therefore be few in comparison.

Since the selection of varieties is a question of locality and of the personal ideals of the grower, it follows that those lists of varieties are most valuable, other things being equal, which are made by the most local and circumscribed societies.

Does spraying pay?—The past season has given strange results in spraying. In very many instances spraying seemed to do no good. Does spraying pay, then? Certainly, the same as tillage and pruning do. We do not know why there were so many unsatisfactory experiences in 1898; but this does not lessen the fact that bugs and fungi should be killed. That spraying pays is as well demonstrated as it is that apple-worms, tent-caterpillars and potato-blight are injurious. Markets often fail, but it does not follow that markets are a nuisance. The safest way is to make it a rule to spray everything every year,

and then to break the rule when one is sure that the combination of circumstances is such that spraying is not necessary. This means that the fruit-farmer must master the reasons and the principles, and then apply them as circumstances demand. As a rule, the better the results of spraying the better has the operator conceived of his own local problems. If the fruit-grower follows this advice, he will probably find himself spraying apples and pears and quinces every year; and he will be more than likely to do the same for plums, grapes and strawberries.

In no one of the applications of science-teaching to fruit-growing has the American so clearly the advantage of the European as in the knowledge of insect and fungous pests and of means of dispatching them. The superiority of the American fruit as a general-market product, is due to a considerable degree to spraying. The American, of all men, should be the last to ask if spraying pays.

L. H. Bailey

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TABLES FOR COMPUTING RATIONS FOR FARM ANIMALS.

By J. L. STONE.

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COMPUTING RATIONS FOR FARM ANIMALS.

For more than a third of a century the subject of feeding to farm animals a "balanced ration" or one that conforms quite closely to a "standard" that has been fixed by carefully conducted experiments with the kind of animals for which it is recommended, has been before American stock feeders. The general utility of feeding standards is almost universally admitted by those who have given the matter study, and the number of feeders who are endeavoring to conform their practices to the standards is continually increasing.

The tables of feeding stuffs and the methods of using them have been much simplified of late years, but judging by the large number of requests from farmers, received by the agricultural papers and the Experiment Stations, for formulas of balanced rations, adapted to the needs of the inquirers, the subject is still too complicated, or the labor involved too great, to be readily accomplished by the ordinary farmer. It is with a view of further simplifying the computation of rations and bringing it within the range of every feeder that the accompanying tables have been prepared. The effort has been to carry the computations as near too completion as possible, so that the user will simply need to take from the table the figures corresponding to the kinds and amounts of the feeds used in the proposed ration and add them together to be able to compare it with the standard. The only advantage claimed for this publication is that by the arrangement of the tables and by the computations made, the labor of formulating rations is very materially reduced, and it is hoped that many who have not heretofore attempted this work for themselves will be encouraged to do so.

Principles of Feeding.

The various substances found in animal bodies may for convenience be grouped under four heads: water; ash, or mineral matter; fat, and nitrogenous matter or protein. These sub-

stances occur in the animal body in somewhat varying proportions, depending upon age, condition, treatment, etc.

Water is an essential constituent of the animal body and constitutes from 40 to 60 per cent of its live weight. Ash occurs mainly in the bones and constitutes from two to five per cent of the live weight. The fat occurs in greatly varying proportions, but rarely is less than six or more than thirty per cent. All those substances containing nitrogen are classed as protein. They constitute an important group of which washed lean meat and the white of egg may be taken as types. They contain about 16 per cent of the element nitrogen and are the only class into the composition of which this element enters. All the working machinery of the body, such as flesh, skin, bones, hair, internal organs, brain and nerves, contain a large proportion of protein.

COMPOSITION OF FOOD MATERIALS.

The same four groups of substances found in animal bodies, viz.: water, ash, fat and protein, are also found in the food they consume and in addition the food of herbivorous animals contains a class called carbohydrates.

Water.—All food stuffs, no matter how dry they may seem, contain a considerable amount of water. In grains and dried fodders it ranges from 8 to 15 per cent of the material, in green forage and silage it is about 80 per cent, while in some roots it amounts to 90 per cent. While water is essential to animal life and the water in the food fulfills the same function as that drunk by the animal, we do not value food materials for the water they contain, and computions are based upon the water-free or dry matter.

Ash.—When a food stuff is burned till the organic matter is all driven off the residue is the ash. It is composed largely of lime, magnesia, potash, soda, iron, chlorine, and carbonic, sulfuric and phosphoric acids. The ash of the food is the source of the mineral matter of the animal body and as such is of great importance. Ordinary combinations of feeding stuffs, however, contain an abundant supply of mineral matter for the use of the animal, so

it is not a matter of practical concern except as it has a bearing on the mineral elements of fertility in the manure.

Fats.—This group embraces the materials which may be dissolved from a feeding stuff by either. It includes, besides the true fats, wax and coloring matter. Fat in the food may be either stored in the body as fat, or burned to produce heat and energy.

Carbohydrates.—This term includes two groups, nitrogen-free extract, such as starch, sugar, gum, etc., and fiber or the woody part of plants. The former are quite freely digested, the latter much less so, though fulfilling the same function to the extent it is digested. The carbohydrates constitute the largest part of vegetable foods. They are not stored in the animal body as such, but are converted into fat or used (burned) to produce heat and energy.

Since the carbohydrates and fat serve nearly the same purpose in the animal economy, they may, for convenience, be grouped together. Experiments, however, have shown that fat is about 2¼ times as effective as a food as are the carbohydrates. Hence it is customary to multiply the amount of fat by 2¼ to reduce it to a "starch equivalent" before adding it to the amount of the carbohydrates.

Protein.—The protein of foods, like that of the animal body is characterized by containg nitrogen. It therefore, is frequently termed "*nitrogenous* matter." The term *albumenoids* is sometimes used to designate this group, though it more correctly implies a certain class of protein substances. The function of protein in the food is, first of all, to build up and repair the working machinery of the body, and to supply protein for the production of milk, wool, etc. For no other food constituent can fulfill this function.

The importance of a sufficient supply of protein in the ration is, therefore, apparent. If in excess of the amount required to build up and repair the waste of the body the protein may be converted into fat and deposited as such or used to produce heat and energy. Its efficiency for these purposes is about the same as the carbohydrates, but as it is usually far more expensive to supply than the carbohydrates, economy would dictate that only so much should be supplied to the animal as will suffice to repair

the wastes of the animal machinery and build up new growth in case of growing animals, or for the production of milk, wool, etc.

COMPOUNDING OF RATIONS.

Nutritive ratio.—Since the protein on the one hand and the carbohydrates and fat on the other, serve, in the main, different purposes in the animal economy, it becomes evident that the relative amounts of these nutritients in the food are important. This relation is expressedas the "nutritive ratio," which means the relation of digestible protein to digestible carbohydrates and fat—the fat having been multiplied by 2¼ before adding to the carbohydrates, as explained above. The nutritive ratio is found by dividing the carbohydrates, plus 2¼ times the fat, by the protein. In the accompanying table, No. II, the sum of the carbohydrates and fat, thus obtained, is given in the third column, which divided by the protein as given in the second column gives the second term of the nutritive ratio in the fifth column.

A feeding stuff having a large proportion of carbohydrates and fat as compared to protein is said to have a "wide" nutritive ratio, while one having a small proportion of carbohydrates and fat as compared to protein has a "narrow" ratio. While these terms are relative, it may be said that a ratio greater than 1:6 is wide, while one less than 1:5 is narrow. The composition of feeding stuffs, that is the proportion in which the different nutrients occur, is determined by chemical analysis, but the amount of each nutrient that is actually digestible has been determined by careful experiments with living animals. Only the digestible nutrients are considered in the tables given in this publication.

Feeding Standards.—The amount of nutrients required and the proportions in which each should be given, varies with the kind of animal and the purpose for which it is kept: whether it is growing, being fattened, doing work, or producing milk or wool. Thus an ox at rest requires less food and the various nutrients in different proportions than an ox at work; a cow producing milk requires more food and the nutrients differently balanced than one not producing.

Various investigators have condensed the results of many experiments and much practical experience into what are called

"feeding standards," which attempt to state what is general, and under average collections, a good ration for the purpose in view. While these standards cannot be considered as mathemetically exact, still large practical experience has demonstrated their great value as aids to feeders.

In Table I, under the title of Feeding Standards, are given the approximate requirements of various classes of animals and under varying conditions. These standards are mostly from German sources, but they have been found very helpful to American feeders. They are presented here as arranged by Armsby, in Circular of Information No. 1, "Computation of Rations for Farm Animals," Penna. State College. The standards are for animals of 1,000 lbs. live weight, and may be increased or diminished for larger or smaller animals, though it is probable that the individuality of the animal, its power to assimilate and produce, will have more to do with the varying of the ration than its weight. It is permissible, perhaps, to depart from the amounts given in the first column under the head of "Dry Matter," more than in any other way. The digestive apparatus of farm animals is elastic and accommdates itself quite readily to the varying bulk of its food. In the last column is given the nutritive ratio, which should, perhaps, be adhered to with some care, trusting to the appetite of the animal (which will be controlled largely by its power of digesting and producing) to indicate the amount of nutrients required. As a rule the most rapid fattening or growth and abundant production are most economical, and these results are best secured by feeding an abundant and well balanced ration (well up to the limit of the animal's appetite) while the dry matter is not permitted to rise much above the standard.

These standards presuppose comfortable stables for the animals during cold weather. If the stables are not comfortable, make them so if possible, but if the animals must be exposed to cold either in doors or out it will be well to increase the amount of carbohydrates in the rations. On the other hand if the stables are so constructed that the temperature never falls below 32° F., a ration even narrower than that given in the standards may be fed to advantage.

TABLE I.

Feeding Standards.

A—Per day and 1,000 pounds live weight.*

	Dry matter.	Digestible. Protein	Digestible. Carbohydrates and fat.	Digestible. Total.	Nutritive ratio.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	
Oxen at rest in stall	17.5	0.7	8.3	9.0	1:11.9
Wool sheep, coarser breeds	20.0	1.2	10.8	12.0	1:9.0
Wool sheep, finer breeds	22.5	1.5	12.0	13.5	1:8.0
Oxen moderately worked	24.0	1.6	12.0	13.0	1:7.5
Oxen heavily worked	26.0	2.4	14.3	16.7	1:6.0
Horses lightly worked	20.0	1.5	10.4	11.9	1:6.9
Horses moderately worked	21.0	1.7	11.8	13.5	1:6.9
Horses heavily worked	23.0	2.3	14.3	16.6	1:6.2
Milk cows, Wolff's standard	24.0	2.5	13.4	15.9	1:5.4
Milk cows, Wisconsin standard	24.5	2.2	14.9	17.1	1:6.8
Fattening oxen, preliminary period	27.0	2.5	16.1	18.6	1:6.4
Fattening oxen, main period	26.0	3.0	16.4	19.4	1:5.5
Fattening oxen, finishing period	25.0	2.7	16.2	18.9	1:6.0
Fattening sheep, preliminary period	26.0	3.0	16.3	19.3	1:5.4
Fattening sheep, main period	25.0	3.5	15.8	19.3	1:4.5
Fattening swine, preliminary p'riod	36.0	5.0	27.5	32.5	1:5.5
Fattening swine, main period	31.0	4.0	24.0	28.0	1:6.0
Fattening swine, finishing period	23.5	2.7	17.5	20.2	1:6.5
Growing cattle:					
Age. Months — *Average live weight per head*					
2–3 — 150 lbs	22.0	4.0	18.3	22.3	1:4.6
3–6 — 300 lbs	23.4	3.2	15.8	19.0	1:4.9
6–12 — 500 lbs	24.0	2.5	14.9	17.4	1:6.0
12–18 — 700 lbs	24.0	2.0	13.9	15.9	1:7.0
18–24 — 850 lbs	24.0	1.6	12.7	14.3	1:8.0
Growing sheep:					
5–6 — 56 lbs	28.0	3.2	17.4	20.6	1:5.4
6–8 — 67 lbs	25.0	2.7	14.7	17.4	1:5.4
8–11 — 75 lbs	23.0	2.1	12.5	14.6	1:6.0
11–15 — 82 lbs	22.5	1.7	11.8	13.5	1:7.0
15–50 — 85 lbs	22.0	1.4	11.1	12.5	1:8.0
Growing fat pigs:					
2–3 — 50 lbs	42.0	7.5	30.0	37.5	1:4.0
3–5 — 100 lbs	34.0	5.0	25.0	30.0	1:5.0
5–6 — 125 lbs	31.5	4.3	23.7	28.0	1:5.5
6–8 — 170 lbs	27.0	3.4	20.4	23.8	1:6.0
8–12 — 250 lbs	21.0	2.5	16.2	18.7	1:6.5

B—Per day and per head.

	Dry matter.	Protein	Carbohydrates and fat.	Total.	Nutritive ratio.
Growing cattle:					
2–3 — 150 lbs	3.3	0.6	2.8	3.4	1:4.6
3–6 — 300 lbs	7.0	1.0	4.9	5.9	1:4.9
6–12 — 500 lbs	12.0	1.3	7.5	8.8	1:6.0
12–18 — 700 lbs	16.8	1.4	9.7	11.1	1:7.0
18–24 — 850 lbs	20.4	1.4	11.1	12.5	1:8.0
Growing sheep:					
5–6 — 56 lbs	1.6	0.18	0.974	1.154	1:5.4
6–8 — 67 lbs	1.7	0.18	0.981	1.161	1:5.4
8–11 — 75 lbs	1.7	0.16	0.953	1.113	1:6.0
11–15 — 82 lbs	1.8	0.14	0.975	1.115	1:7.0
15–20 — 85 lbs	1.9	0.12	0.955	1.075	1:8.0
Growing fat swine:					
2–3 — 50 lbs	2.1	0.38	1.50	1.88	1:4.0
3–5 — 100 lbs	3.4	0.50	2.50	3.00	1:5.0
5–6 — 125 lbs	3.9	0.54	2.96	3.50	1:5.5
6–8 — 170 lbs	4.6	0.58	3.47	4.05	1:6.0
8–12 — 250 lbs	5.2	0.62	4.05	4.67	1:6.5

*The fattening rations are calculated for 1,000 lbs., live weight at the beginning of the fattening.

Table II gives a list of the feeding stuffs in most common use in New York state. Column one is headed "dry matter;" column two, "digestible protein;" column three, "digestible carbohydrates + (fat × 2¼);" column four, "total" (which is the sum of two and three); column five, "nutritive ratio." In each of these columns is given the computations of the various food stuffs from one pound up to the amount that is likely to be used in compounding any ration. In the case of the coarse fodders, to save space, the increase is made by more than one pound at a time, but intermediate amounts can readily be obtained from the table if desired. In no case are the calculations for *ten lbs.* of a feeding stuff given, as these can be obtained at once from the figures for one pound, by simply moving the decimal point one place to the right.

These computations are based upon the table of "Average Digestible Nutrients in American Feeding Stuffs" given in Prof. W. A. Henry's recent book, "Feeds and Feeding." The aim has been to carry the computations involved in formulating rations as near completion as possible, and to present the figures in such simple form that no feeder will have difficulty in comparing the ration he is feeding with the standards and correcting it, if necessary, to conform thereto.

TABLE NO. 11.

DIGESTIBLE NUTRIENTS IN THE STATED AMOUNTS OF THE MORE COMMON FEEDING STUFFS.

Kind and amount of food.	Total dry matter	Pounds of digestible nutrients.			Nutritive ratio.
		Protein.	Carbohydrates + (fat × 2.25).	Total.	
SOILING FODDER.					
Fodder corn, 1 lb.	.20	.010	.125	.135	1:12.5
" " 5 lbs.	1.00	.050	625	.675	
" " 15 "	3.00	.150	1.875	2.025	
" " 20 "	4.00	.200	2.500	2.700	
" " 25 "	5.00	.250	3.125	3.375	
" " 30 "	6.00	.300	3.750	4.050	
" " 35 "	7.00	.350	4.375	4.725	
" " 40 "	8.00	.400	5.000	5.400	
Peas and oats, 1 lb.	.16	.018	.076	.094	1:4.2
" " 5 lbs.	.80	.090	.380	.470	
" " 15 "	2.40	.270	1.140	1.410	
" " 20 "	3.20	.360	1.520	1.880	
" " 25 "	4.00	.450	1.900	2.350	
" " 30 "	4.80	.540	2.280	2.820	
" " 35 "	5.60	.630	2.660	3.290	
" " 40 "	6.40	.720	3.040	3.760	
Peas and barley	.16	.017	.077	.094	1:4.5
Practically the same as peas and oats.					
Red clover, 1 lb.	.29	.029	.164	.193	1:5.6
" " 5 lbs.	1.45	.145	.820	.965	
" " 15 "	4.35	.435	2.460	2.895	
" " 20 "	5.80	.580	3.280	3.860	
" " 25 "	7.25	.725	4.100	4.825	
" " 30 "	8.70	.870	4.920	5.790	
" " 35 "	10.15	1.015	5.740	6.755	
" " 40 "	11.60	1.160	6.560	7.720	
Alfalfa, 1 lb.	.28	.039	.138	.177	1:3.5
" 5 lbs	1.40	.195	.690	.885	
" 15 "	4.20	.585	2.070	2.655	
" 20 "	5.60	.780	2.760	3.540	
" 25 "	7.00	.975	3.450	4.425	
" 30 "	8.40	1.170	4.140	5.310	
" 35 "	9.80	1.365	4.830	6.195	
" 40 "	11.20	1.560	5.520	7.080	
Hungarian grass, 1 lb.	.29	.020	.169	.189	1:8.4
" " 5 lbs.	1.45	.100	.845	.945	
" " 15 "	4.35	.300	2.535	2.835	
" " 20 "	5.80	.400	3.380	3.780	
" " 25 "	7.25	.500	4.225	4.725	
" " 30 "	8.70	.600	5.070	5.670	
" " 35 "	10.15	.700	5.915	6.615	
" " 40 "	11.60	.800	6.760	7.560	

TABLE NO. II.—*Continued.*

Kind and amount of feed.	Total dry matter.	Pounds of digestible nutrients. Protein.	Carbohydrates + (fat × 2.25.)	Total.	Nutritive ratio.
Corn silage 1 lb.	.21	.009	.129	.138	1:14.3
" " 5 lbs.	1.05	.045	.645	.690	
" " 15 "	3.15	.135	1.935	2.070	
" " 20 "	4.20	.180	2.580	2.760	
" " 25 "	5.25	.225	3.225	3.450	
" " 30 "	6.30	.270	3.870	4.140	
" " 35 "	7.35	.315	4.515	4.830	
" " 40 "	8.40	.360	5.160	5.520	
" " 45 "	9.45	.405	5.805	6.210	
" " 50 "	10.50	.450	6.450	6.900	
ROOTS AND TUBERS.					
Potatoes 1 lb.	.21	.009	.165	.174	1:18.3
" 5 lbs.	1.05	.045	.825	.870	
" 15 "	3.15	.135	2.475	2.610	
" 20 "	4.20	.180	3.300	3.480	
" 25 "	5.25	.225	4.125	4.350	
Beet, mangel 1 lb.	.09	.011	.056	.067	1:5.1
" " 5 lbs.	.45	.055	.280	.335	
" " 15 "	1.35	.165	.840	1.005	
" " 20 "	1.80	.220	1.120	1.340	
" " 25 "	2.25	.275	1.400	1.675	
" " 30 "	2.70	.330	1.680	2.010	
Beet, sugar 1 lb.	.13	.011	.104	.115	1:9.4
" " 5 lbs.	.65	.055	.520	.575	
" " 15 "	1.95	.165	1.560	1.725	
" " 20 "	2.60	.220	2 080	2.300	
" " 25 "	3.25	.275	2.600	2.875	
" " 30 "	3.90	.330	3.120	3.450	
Carrot 1 lb.	.11	.008	.082	.090	1:10.3
" 5 lbs.	.55	.040	.410	.450	
" 15 "	1.65	.120	1.230	1.305	
" 20 "	2.20	.160	1.640	1.800	
" 25 "	2.75	.200	2.050	2.250	
" 30 "	3.30	.240	2.460	2.700	
Flat Turnip 1 lb.	.10	.01	.077	.087	1:7.7
" " 5 lbs.	.50	.05	.385	.435	
" " 15 "	1.50	.15	1.155	1.350	
" " 20 "	2.00	.20	1.540	1.740	
" " 25 "	2.50	.25	1.925	2.175	
" " 30 "	3.00	.30	2.310	2.610	
HAY AND STRAW.					
Timothy 1 lb.	.87	.028	.465	.493	1:16.6
" 3 lbs.	2.61	.084	1.395	1.479	
" 5 "	4.35	.140	2.325	2.465	

TABLE NO. II.—*Continued.*

Kind and amount of feed.	Total dry matter.	Pounds of digestible nutrients. Protein.	Carbohydrates + (fat × 2.25.)	Total.	Nutritive ratio.
Timothy, 7 lbs.	6.09	.196	3.255	3.451	
" 8 "	6.96	.224	3.720	3.944	
" 9 "	7.83	.252	4.185	4.437	
" 12 "	10.44	.336	5.580	5.916	
" 15 "	13.05	.420	6.975	7.395	
" 18 "	15.66	.504	8.370	8.874	
" 20 "	17.40	.560	9.300	9.860	
Mixed grasses and clover, 1 lb.	.87	.062	.460	.522	1:7.4
" 3 lbs	2.61	.186	1.381	1.566	
" 5 "	4.35	.310	2.300	2.610	
" 7 "	6.09	.434	3.220	3.654	
" 8 "	6.96	.496	3.680	4.176	
" 9 "	7.83	.558	4.140	4.698	
" 12 "	10.44	.744	5.520	6.264	
" 15 "	13.05	.930	6.900	7.830	
" 18 "	15.66	1.116	8.280	9.396	
" 20 "	17.40	1.240	9.200	10.440	
Hungarian hay, 1 lb.	.92	.045	.546	.591	1:12.1
" " 3 lbs.	2.76	.135	1.638	1.773	
" " 5 "	4.60	.225	2.730	2.955	
" " 7 "	6.44	.315	3.822	4.137	
" " 8 "	7.36	.360	4.368	4.728	
" " 9 "	8.28	.405	4.914	5.319	
" " 12 "	11.04	.540	6.552	7.092	
Red clover hay, 1 lb.	.85	.068	.396	.464	1:5.8
" " 3 lbs	2.55	.204	1.188	1.392	
" " 5 "	4.25	.340	1.980	2.320	
" " 7 "	5.95	.476	2.772	3.248	
" " 8 "	6.80	.544	3.168	3.712	
" " 9 "	7.65	.612	3.564	4.176	
" " 12 "	10.20	.816	4.752	5.568	
" " 15 "	12.75	1.020	5.940	6.960	
" " 18 "	15.30	1.224	7.128	8.352	
" " 20 "	17.00	1.360	7.920	9.280	
Alfalfa hay, 1 lb	.92	.110	.423	.533	1:3.8
" " 3 lbs.	2.76	.330	1.269	1.599	
" " 5 "	4.60	.550	2.115	2.665	
" " 7 "	6.44	.770	2.961	3.731	
" " 8 "	7.36	.880	3.384	4.264	
" " 9 "	8.28	.990	3.807	4.797	
" " 12 "	11.04	1.320	5.076	6.396	
" " 15 "	12.80	1.650	6.345	7.995	
" " 18 "	16.56	1.980	7.614	9.594	
" " 20 "	18.40	2.200	8.460	10.660	

TABLE II.—*Continued.*

Kind and amount of feed.	Total Dry Matter.	Pounds of digestible nutrients. Protein.	Corbohydrates + (fat 2.25).	Total.	Nutritive ratio.
Corn fodder 1 lb.	.58	.025	.373	.398	1:14.9
" 5 lbs	2.90	.125	1.865	1.990	
" 8 "	4.64	.200	2.984	3.184	
" 12 "	6.96	.300	4.476	4.776	
" 15 "	8.70	.375	5.595	5.970	
" 18 "	10.44	.450	6.714	7.164	
" 20 "	11.60	.500	7.460	7.960	
Corn stover 1 lbs.	.60	.017	.340	.357	1:19.9
" 5 lbs	3.00	.085	1.720	1.785	
" 8 "	4.80	.136	2.720	2.856	
" 12 "	7.20	.204	4.080	4.284	
" 15 "	9.00	.255	5.160	5.355	
" 18 "	10.80	.306	6.120	6.426	
" 20 "	12.00	.340	6.880	7.140	
Pea-vine straw 1 lb.	.86	.043	.341	.384	1: 7.9
" " 3 lbs.	2.58	.129	1.023	1.152	
" " 5 "	4.30	.215	1.705	1.920	
" " 8 "	6.88	.344	2.728	3.072	
" " 12 "	10.32	.516	4.092	4.608	
" " 15 "	12.90	.645	5.115	5.760	
*Bean straw 1 lb	.95	.036	.397	.433	1:11:0
" 2 lbs.	1.90	.072	.794	.866	
" 3 "	2.85	.108	1.191	1.299	
" 4 "	3.80	.144	1.588	1.732	
" 5 "	4.75	.180	1 985	2.165	
" 7 "	6.65	.252	2.779	3.031	
" 9 "	8.55	.324	3.573	3.897	
" 12 "	11.40	.432	4.764	5.196	
Wheat straw 1 lb.	.90	.004	.372	.376	1:93.
" 3 lbs.	2.70	.012	1.016	1.128	
" 5 "	4.50	.020	1.860	1.880	
" 8 "	7.20	.032	2.976	3.008	
" 12 "	10.80	.048	4.064	4.512	
" 15 "	13.50	.060	5.580	5.640	
Oat straw 1 lb.	.91	.012	.404	4.16	1:33.6
" 3 lbs.	2.73	.036	1.212	1.248	
" 5 "	4.55	.060	2.020	2.080	
" 8 "	7.28	.096	3.232	3.328	
" 12 "	10.92	.144	4.848	4.992	
" 15 "	13.65	.180	6.060	6.240	
GRAIN.					
Corn (av.) 1 lb.	.89	.079	.764	.843	1: 9.7
" 2 lbs.	1.78	.158	1.528	1.686	
" 3 "	2.67	.237	2.292	2.529	

* Computed from recent analyses by G. W. Cavanaugh.

TABLE II.—*Continued.*

Kind and amount of feed.	Total dry matter.	Pounds of digestible nutrients.			Nutritive ratio.
		Protein.	Carbohydrates+ (fat × 2.25.)	Total.	
Corn (av.) 4 lbs.	3.56	.316	3.056	3.372	
" 5 "	4.45	.395	3.820	4.215	
" 6 "	5.34	.474	4.584	5.058	
" 7 "	6.23	.553	5.348	4.901	
" 8 "	7.12	.632	6.112	6.744	
" 9 "	8.01	.711	6.876	7.587	
Wheat, 1 lb.	.90	.102	.730	.832	1:7.2
" 2 lbs.	1.80	.204	1.460	1.664	
" 3 "	2.70	.306	2.190	2.496	
" 4 "	3.60	.408	2.920	3.328	
" 5 "	4.50	.510	3.650	4.160	
" 6 "	5.40	.612	4.380	4.992	
Rye, 1 lb.	.88	.099	.700	.499	1:7.1
" 2 lbs.	1.76	.198	1.400	1.598	
" 3 "	2.64	.297	2.100	2.397	
" 4 "	3.52	.396	2.800	3.196	
" 5 "	4.40	.495	3.500	3.995	
" 6 "	5.28	.594	4.200	4.794	
Barley, 1 lb	.89	.087	.692	.779	1:7.9
" 2 lbs.	1.78	.174	1.384	1.558	
" 3 "	2.67	.261	2.076	2.337	
" 4 "	3.56	.348	2.768	3.116	
" 5 "	4.45	.435	3.460	3.895	
" 6 "	5.34	.522	4.152	4.674	
Oats, 1 lb.	.89	.092	.568	.660	1:6.2
" 2 lbs.	1.78	.184	1.136	1.320	
" 3 "	2.67	.276	1.704	1.980	
" 4 "	3.56	.368	2.272	2.640	
" 5 "	4.45	.460	2.840	3.300	
" 6 "	5.34	.552	3.408	3.960	
" 7 "	6.23	.644	3.976	4.620	
" 8 "	7.12	.736	4.544	5.280	
" 9 "	8.01	.828	5.112	5.940	
" 12 "	10.68	1.104	6.816	7.920	
" 15 "	13.35	1.380	8.520	9.900	
Buckwheat, 1 lb.	.87	.077	.533	.610	1:6.9
" 2 lbs.	1.74	.154	1.066	1.220	
" 3 "	2.61	.231	1.599	1.830	
" 4 "	3.48	.308	2.132	2.440	
" 5 "	4.35	.385	2.665	3.050	
" 6 "	5.22	.462	3.198	3.660	
" 7 "	6.09	.539	3.731	4.270	
" 8 "	6.96	.616	4.264	4.880	
" 9 "	7.83	.693	4.797	5.490	

TABLE II.—*Continued.*

Kind and amount of feed.	Total dry matter.	Pounds of digestible nutrients. Protein.	Carbohydrates + (fat × 2.25).	Total.	Nutritive ratio.
Peas, 1 lb.	.90	.168	.534	.702	1:3.2
" 2 lbs.	1.80	.336	1.068	1.404	
" 3 "	2.70	.504	1.602	2.106	
" 4 "	3.60	.672	2.136	2.808	
" 5 "	4.50	.840	2.670	3.510	
" 6 "	5.40	1.008	3.204	4.212	
" 7 "	6.30	1.176	3.738	4.914	
" 8 "	7.20	1.344	4.272	5.616	
" 9 "	8.10	1.512	4.806	6.318	
MILL PRODUCTS.					
Corn and cob meal, 1 lb.	.85	.044	.665	.709	1:15.1
" " 2 lbs.	1.70	.088	1.330	1.418	
" " 3 "	2.55	.132	1.995	2.127	
" " 4 "	3.40	.176	2.660	2.836	
" " 5 "	4.25	.220	3.325	3.545	
" " 6 "	5.10	.264	3.990	4.254	
" " 7 "	5.95	.308	4.655	4.963	
" " 8 "	6.80	.352	5.320	5.672	
" " 9 "	7.65	.396	5.985	6.381	
" " 12 "	10.20	.528	7.980	8.508	
Wheat bran, 1 lb.	.88	.122	.453	.575	1:3.7
" " 2 lbs.	1.76	.244	.906	1.150	
" " 3 "	2.64	.366	1.359	1.725	
" " 4 "	3.52	.488	1.812	2.300	
" " 5 "	4.40	.610	2.265	2.875	
" " 6 "	5.28	.732	2.718	3.450	
" " 7 "	6.16	.854	3.171	4.025	
" " 8 "	7.04	.976	3.624	4.600	
" " 9 "	7.92	1.098	4.077	5.175	
Wheat middlings, 1 lb.	.88	.128	.607	.735	1:4.7
" " 2 lbs.	1.76	.256	1.214	1.470	
" " 3 "	2.64	.384	1.821	2.205	
" " 4 "	3.52	.512	2.428	2.940	
" " 5 "	4.40	.640	3.035	3.675	
" " 6 "	5.28	.768	3.642	4.410	
" " 7 "	6.16	.896	4.249	5.145	
" " 8 "	7.04	1.024	4.856	5.880	
" " 9 "	7.92	1.152	5.463	6.615	
Dark feeding flour, 1 lb.	.90	.135	.658	.793	1:4.9
" " 2 lbs.	1.80	.270	1.316	1.586	
" " 3 "	2.70	.405	1.974	2.379	
" " 4 "	3.60	.540	2.632	3.172	
" " 5 "	4.50	.675	3.290	3.965	

TABLE II.—*Continued.*

Kind and amount of feed.	Total dry matter.	Pounds of digestible nutrients. Protein.	Carbohydrates + (fat × 2.25).	Total.	Nutritive ratio.
Dark feeding flour, 6 lbs.	5.40	.810	3.948	4.758	
" " 7 "	6.30	.945	4.606	5.551	
" " 8 "	7.20	1.080	5.264	6.344	
" " 9 "	8.10	1.215	5.922	7.137	
Low grade flour, 1 lb.	.88	.082	.647	.729	1:7.9
" " " 2 lbs.	1.76	.164	1.294	1.458	
" " " 3 "	2.64	.246	1.941	2.187	
" " " 4 "	3.52	.328	2.588	2.916	
" " " 5 "	4.40	.410	3.235	3.645	
" " " 6 "	5.28	.492	3.882	4.374	
" " " 7 "	6.16	.574	4.529	5.103	
" " " 8 "	7.04	.656	5.176	5.832	
" " " 9 "	7.92	.738	5.823	6.561	
Rye bran, 1 lb.	.88	.115	.548	.663	1:4.8
" " 2 lbs.	1.76	.230	1.096	1.326	
" " 3 "	2.64	.345	1.644	1.989	
" " 4 "	3.52	.460	2.192	2.652	
" " 5 "	4.40	.575	2.740	3.315	
" " 6 "	5.28	690	3.288	3.978	
" " 7 "	6.16	805	3.836	4.641	
" " 8 "	7.04	.920	4.384	5.304	
" " 9 "	7.92	1.035	4.952	5.967	
Buckwheat bran, 1 lb.	.90	.074	.347	.421	1:4.7
" " 2 lbs.	1.80	.148	.694	.842	
" " 3 "	2.70	.222	1.041	1.263	
" " 4 "	3.60	.296	1.388	1.684	
" " 5 "	4.50	.370	1.735	2.105	
" " 6 "	5.40	.444	2.082	2.526	
" " 7 "	6.30	.518	2.429	2.847	
" " 8 "	7.20	.592	2.776	3.368	
" " 9 "	8.10	.666	3.123	3.789	
Buckwheat middlings, 1 lb.	.87	.220	.456	.676	1:2.1
" " 2 lbs.	1.74	.440	.912	1.352	
" " 3 "	2.61	.660	1.368	2.028	
" " 4 "	3.48	.880	1.824	2.704	
" " 5 "	4.35	1.100	2.280	3.380	
" " 6 "	5.22	1.320	2.736	4.056	
" " 7 "	6.09	1.540	3.192	4.732	
" " 8 "	6.96	1.760	3.648	5.408	
" " 9 "	7.83	1.980	4.104	6.084	
BYE-PRODUCTS.					
Malt sprouts, 1 lb.	.90	.186	.409	.595	1:2.2
" " 2 lbs.	1.80	.372	.818	1.190	

TABLE II.—*Continued.*

Kind and amount of feed.	Total dry matter.	Pounds of digestible nutrients. Protein.	Carbohydrates + (fats × 2.25).	Total.	Nutritive ratio.
Malt sprouts 3 lbs.......	2.70	.558	1.227	1.785	
" 4 "	3.60	.744	1.636	2.380	
" 5 "	4.50	.930	2.045	2.975	
" 6 "	5.40	1.116	2.454	3.570	
" 7 "	6.30	1.302	2.863	4.165	
" 8 "	7.20	1.488	3.273	4.760	
" 9 "	8.10	1.674	3.681	5.355	
Brewer's grains, wet 1 lb..	.24	.039	.125	.164	1:3.2
" " 2 lbs.	.48	.078	.250	.328	
" " 3 "	.72	.117	.375	.492	
" " 4 "	.96	.156	.500	.656	
" " 5 "	1.20	.195	.625	.820	
" " 6 "	1.44	.234	.750	.984	
" " 7 "	1.68	.273	.875	1.148	
" " 8 "	1.92	.312	1.000	1.312	
" " 9 "	2.16	.351	1.125	1.476	
" " 11 "	2.64	.429	1.375	1.804	
" " 12 "	2.88	.468	1.500	1.968	
" " 15 "	3.60	.585	1.875	2.460	
Brewer's grains, dry 1 lb.	.92	.157	.478	.635	1:3
" " 2 lbs	1.84	.314	.956	1.270	
" " 3 "	2.76	.471	1.434	1.905	
" " 4 "	3.68	.628	1.912	2.540	
" " 5 "	4.60	.785	2.390	3.175	
" " 6 "	5.52	.942	2.868	3.810	
" " 7 "	6.44	1.099	3.346	4.445	
" " 8 "	7.36	1.256	3.824	5.080	
" " 9 "	8.28	1.413	4.302	5.715	
Gluten feed* 1 lb	.92	.194	.633	.827	1:3.3
" 2 lbs...... .	1.84	.388	1.266	1.654	
" 3 "	2.76	.582	1.899	2.481	
" 4 "	3.68	.776	2.532	3.308	
" 5 "	4.60	.970	3.165	4.135	
" 6 "	5.52	1.164	3.798	4.962	
" 7 "	6.44	1.358	4.431	5.789	
" 8 "	7.36	1.552	5.064	6.616	
Gluten meal 1 lb.........	.92	.258	.656	.914	1:2.5
" 2 lbs........	1.84	.516	1.312	1.828	
" 3 "	2.76	.774	1.968	2.742	
" 4 "	3.68	1.032	2.624	3.656	
" 5 "	4.60	1.290	3.280	4.570	
" 6 "	5.52	1.548	3.936	5.484	
" 7 "	6.44	1.806	4.592	6 398	
" 8 "	7.36	2.064	5.248	7.312	

*From Bulletin of Information No. 1, Penna. State College.

TABLE II.—*Continued.*

Kind and amount of feed.	Total dry matter.	Pounds of digestible nutrients. Protein.	Carbohydrates + (fats × 2.25)	Total.	Nutritive ratio.
Hominy Chops, 1 lb.	.89	.075	.705	.780	1:9.4
" 2 lbs.	1.78	.150	1.410	1.560	
" 3 "	2.67	.225	2.115	2.340	
" 4 "	3.56	.300	2.820	3.120	
" 5 "	4.45	.375	3.525	3.900	
" 6 "	5.34	.450	4.230	4.680	
" 7 "	6.23	.525	4.935	5.460	
" 8 "	7.12	.600	5.640	6.240	
" 9 "	8.01	.675	6.345	7.020	
Linseed meal (old process), 1 lb.	.91	.293	.485	.778	1:1.7
" " 2 lbs.	1.82	.586	.970	1.556	
" " 3 "	2.73	.879	1.455	2.334	
" " 4 "	3.64	1.172	1.940	3.112	
" " 5 "	4.55	1.465	2.425	3.890	
" " 6 "	5.46	1.758	2.910	4.668	
" " 7 "	6.37	2.051	3.395	5.446	
Linseed meal (new process), 1 lb.	.90	.282	.464	.746	1:1.6
" " 2 lbs.	1.80	.564	.928	1.492	
" " 3 "	2.70	.846	1.392	2.238	
" " 4 "	3.60	1.128	1.856	2.984	
" " 5 "	4.50	1.410	2.320	3.730	
" " 6 "	5.40	1.692	2.784	4.476	
" " 7 "	6.30	1.974	3.248	5.232	
Cotton-seed meal, 1 lb.	.92	.372	.444	.816	1:1.2
" " 2 lbs.	1.84	.744	.888	1.632	
" " 3 "	2.76	1.116	1.332	2.448	
" " 4 "	3.68	1.488	1.776	3.264	
" " 5 "	4.60	1.860	2.220	4.080	
" " 6 "	5.52	2.232	2.664	4.896	
" " 7 "	6.44	2.604	3.008	5.712	
" " 8 "	7.36	2.976	3.552	6.528	
" " 9 "	8.28	3.348	3.996	7.344	
MISCELLANEOUS.					
Cabbage, 1 lb.	.15	.018	.091	.109	1:5.1
" 5 lbs.	.75	.090	.445	.545	
" 15 "	2.25	.270	1.365	1.635	
" 20 "	3.00	.360	1.820	2.180	
" 25 "	3.75	.450	2.275	2.725	
" 30 "	4.50	.540	2.730	3.270	
" 35 "	5.25	.630	3.185	3.815	
" 40 "	6.00	.720	3.640	4.360	

TABLE II.—*Continued.*

Kind and amount of feed.	Total dry matter.	Pounds of digestible nutrients.			Nutritive ratio.
		Protein.	Carbohydrates + (fat × 2.25).	Total.	
Sugar beet leaves, 1 lb..	.12	.017	.051	.068	
" " 5 lbs.	.60	.085	.255	.340	
" " 15 " ..	1.80	.255	.765	1.020	
" " 20 " ..	2.40	.340	1.020	1.360	
" " 25 " ..	3.00	.425	1.275	1.700	
" " 30 " ..	3.60	.510	1.530	2.040	
" " 35 " ..	4.20	.595	1.785	2.380	
" " 40 " ..	4.80	.680	2.040	2.720	
Sugar beet pulp, 1 lb.....	.10	.006	.073	.079	1:12
" " 5 lbs....	.50	.030	.365	.395	
" " 15 "	1.50	.090	1.095	1.185	
" " 20 "	2.00	.120	1.460	1.580	
" " 25 "	5.20	.150	1.825	1.975	
" " 30 "	3.00	.180	2.190	2.370	
" " 35 "	3.50	.210	2.555	2.765	
" " 40 "	4.00	.240	2.920	2.160	
Beet molasses, 1 lb.......	.79	.091	.595	.686	1:6.5
" " 2 lbs......	1.58	.182	1.190	1.372	
" " 3 "	2.37	.273	1.785	2.058	
" " 4 "	3.16	.364	2.380	2.744	
" " 5 "	3.95	.455	2.975	2.430	
" " 6 "	4.74	.546	3.570	4.116	
" " 7 "	5.53	.637	4.165	4.802	
" " 8 "	6.32	.728	4.760	5.488	
" " 9 "	7.11	.819	5.355	6.174	
Apple pomace, 1 lb.*. ...	.233	.011	.164	.175	1:14.9
" " 5 lbs......	1.165	.055	.820	.875	
" " 15 "	3.495	.165	2.460	2.625	
" " 20 "	4.660	.220	3.280	3.500	
" " 25 "	5.825	.275	4.100	4.375	
" " 30 "	6.990	.330	4.920	5.250	
" " 35 "	8.155	.385	5.740	6.125	
" " 40 "	9.320	.440	6.560	7.000	
Skim milk gravity, 1 lb..	.096	.031	.065	.096	1:2.1
" " 5 lbs.	.480	.155	.325	.480	
" " 8 " ..	.768	.248	.520	.768	
" " 12 " .	1.152	.372	.780	1.152	
" " 15 " ..	1.440	.465	.975	1.440	
" " 20 " ..	1.920	.620	1.300	1.920	
" " 25 " ..	2.400	.775	1.625	2.400	
" " 30 " ..	2.880	.930	1.950	2.880	
Skim milk centrifugal, 1 lb.	.094	.029	.059	.088	1.2
" " 5 lbs.	.470	.145	.295	.440	

*From Bulletin of Information No. 1, Penna. State College.

TABLE II.—*Continued.*

Kind and amount of feed.	Total dry matter.	Pounds of digestible nutrients. Protein.	Carbohydrates + (fat × 2.25).	Total.	Nutritive ratio.
Skim milk centrifugal, 8 lbs.	.752	.232	.472	.704	
" " 12 "	1.128	.348	.708	1.056	
" " 15 "	1.410	.435	.885	1.320	
" " 20 "	1.880	.580	1.180	1.760	
" " 25 "	2.350	.725	1.475	2.200	
" " 30 "	2.820	.870	1.770	2.620	
Buttermilk, 1 lb........	.10	.039	.065	.104	1:1.7
" 5 lbs	.50	.195	.325	.520	
" 8 "	.80	.312	.520	.832	
" 12 "	1.20	.468	.780	1.248	
" 15 "	1.50	.585	.975	1.560	
" 20 "	2.00	.780	1.300	2.080	
" 25 "	2.50	.975	1.625	2.600	
" 30 "	3.00	1.170	1.950	3.120	

To illustrate how these tables may be used, we will examine a system of feeding which the writer observed the present season in a certain section of the state, and was told was quite extensively practiced. The section referred to is devoted almost exclusively to dairying, and timothy hay constitutes the greater portion of the course fodder during the feeding season. Oats are about the only grain grown. Corn is purchased and ground with the oats, in about equal weights, to make "chop" which is fed with the hay. The cows will not greatly vary from 1000 lbs. live weight. While these cows are in full flow of milk in the spring before pasture is ready, they are fed about 20 pounds of hay and 8 pounds of chop per day. Turning to the tables we find that 20 pounds of hay, 4 pounds of oats and 4 pounds of corn contain digestible nutrients as follows :—

	Dry matter.	Protein.	C. H. and Fat.	Total.	Nutritive Ratio.
20 lbs. hay............	17.40	.560	9.300	9.860	
4 lbs. oats............	3.56	.368	2.772	2.640	
4 lbs. corn............	3.56	.316	3.056	3.372	
Total............	24.52	1.244	14.628	15.872	1:11.7
Wolff's Standard.........	24.00	2.5	13.4	15.9	1: 5.4

Upon comparison of the nutrients furnished by this ration with Wolff's standard as given in Table I, it is discovered that while the dry matter and total nutrients are not far out of the way, the protein is much too small, the carbohydrates and fat are somewhat too great, while the nutritive ratio is far too wide.

This result might readily have been foreseen had we paused a moment to note the nutritive ratio of each of the three foods entering into the ration. They are, timothy hay, 1:16.6; oats, 1:6.2; corn, 1:9.7. Neither of them is as narrow as the standard, and it is impossible to combine them into a ration that is approximately balanced. As corn is a purchased product the natural suggestion is that the corn should be replaced by some food having a high proportion of protein, or in other words, a very narrow nutritive ratio. Consulting the table, it is found that among such are linseed meal, cotton-seed meal, gluten feed, malt sprouts, buckwheat middlings, etc. As buckwheat middlings is a N. Y. State product and can readily be put in stock during the winter, it is suggested to substitute it for the corn in the ration. Again taking the figures from the table we have :—

	Dry matter.	Protein.	C. H. and Fat.	Total.
20 lbs. timothy hay......	17.40	.560	9.300	9.860
4 lbs. oats............	3.56	.368	2.272	2.640
4 lbs. buckwheat mid's.	3.48	.880	1.824	2.704
Total.............	24.44	1.808	13.396	15.204
Nutritive ratio		1:7.4		

When this ration is much improved over the previous one and will produce a more abundant flow of milk it is still too wide to produce the best results.

If the timothy hay is reduced two pounds, and two pounds of cotton-seed meal put in its place we get :—

	Dry matter.	Protein.	C. H. and Fat.	Total.
18 lbs. timothy hay......	15.66	.504	8.370	8.874
4 lbs. oats	3.56	.368	2.272	2.640
4 lbs. buckwheat mid's.	3.48	.880	1.824	2.704
2 lbs. cotton-seed meal..	1.84	.744	.888	1.632
Total	24.54	2.496	13.354	15.850
Nutritive ratio		1:5.3		

This ration corresponds very closely to the standard and while the purchase of the cotton-seed meal will add somewhat to the expense still it is the experience of careful feeders that the increased production will abundantly pay for thus securing a proper balance to the ration.

The same result may be obtained by using other feeding stuffs having a narrow nutritive ratio. The question is likely to be raised, which of the various feeding stuffs offered in the market may most economically be used in supplementing the home grown foods to produce a balanced ration? This question is best answered by formulating properly balanced rations containing each of the foods under consideration, and by assigning the actual market value per pound to each of the constituents of the ration, its cost is readily ascertained and the cheapest may be selected.

A second edition of Bulletin 154 has become necessary by reason of the great demand for it which has been made by others than those who are regularly on our mailing list. Many of the letters received indicate that the value of the bulletin might be increased if a table giving the water, ash, nitrogen, phosphoric acid and potash were appended, of the feeds mentioned in the bulletin. The mineral constituents in the following table have been compiled from "The Fertility of the Land." The amounts given, of water, ash, nitrogen, phosphoric acid and potash, are for one thousand pounds of feeds. To determine the amounts in one hundred pounds, move the decimal point one place to the left. The right hand column gives the estimated values of one ton ; nitrogen, phosphoric acid and potash being values at fourteen, four and one-half, and four and one-half cents per pound respectively.

When the feeds enumerated in the following table are fed to miscellaneous classes of animals, fully one-half of the valuable fertilizing constituents in the rations are found in the solid and liquid excrements. Non-producing and fattening animals retain comparatively small amounts, and young animals and cows in milk comparatively large amounts of the three valuable manurial elements contained in the rations consumed.

It is true that the three elements of chief value in manures

TABLE No. III.
ELEMENTS OF FERTILITY IN 1,000.

		No. of analyses.	Water in 1000 lbs.	Ash in 1000 lbs.	Nitrogen in 1000 lbs.	Phosphoric acid in 1000 lbs.	Potash in 1000 lbs.	Estimated value per ton.
1	Maize fodder, (green).	45	828	14.7	1.6	1.1	3.9	$ .90
2	Peas and oats, (green).		467	16.05	2.8	1.65	6.25	1.50
3	Barley and peas, (green).		755	16.7	2.7	1.8	5.05	1.38
4	Red clover, (green).	42	790	16	4.6	1.5	4.8	1.86
5	Alfalfa, (green).	11	760	22.1	6.2	1.5	3.5	2.18
6	Hungarian grass, (green).	6	870	12	3.2	.7	4.7	1.38
7	Corn silage, (green).		779	———	1.4	1.1	3.7	.82
8	Potatoes.	197	750	11	1.4	1.6	5.7	1.04
9	Mangle-werzel.		873	12.2	1.7	.9	3.8	.90
10	Beets, (sugar).	68	820	8.1	1.7	.8	3.7	.88
11	Carrots.	63	870	10	1.2	.9	2.6	.65
12	Timothy hay.	69	143	41.1	4.4	5.0	14.1	2.95
13	Mixed hay.	393	137	64.5	9.9	4.1	13.2	4.33
14	Hungarian hay.		77	61.8	7.2	3.5	13.0	3.50
15	Red clover hay.	178	170	62.1	10.8	5.5	18.7	5.20
16	Alfalfa hay.	117	153	80.2	17.6	6.1	17.9	7.08
17	Corn fodder with ears.		92	37.4	4.0	2.9	14.0	2.64
18	Corn stover.		150	45.3	2.7	3.8	16.4	2.57
19	Pea vine straw.	53	136	66.0	6.8	3.5	10.2	3.14
20	Wheat straw.	80	136	53.0	.64	2.2	6.3	.94
21	Oat straw.	55	145	57.0	1.9	2.8	17.7	2.38
22	Indian corn.	149	130	14.8	12.6	5.7	3.7	4.34
23	Wheat.	1358	134	17.1	16.3	8.7	5.5	5.84
24	Rye.	257	134	19.8	15.8	8.6	5.8	5.72
25	Barley.	1128	143	24.8	13.9	7.9	4.8	5.04
26	Oats.	560	133	31.0	14.7	6.9	4.8	5.16
27	Buckwheat.	20	141	27.7	12.3	6.9	3.0	4.34
28	Peas.	118	140	28.1	26.8	8.4	10.1	9.16
29	Corn-cob meal.		90	———	7.0	5.7	4.7	2.90
30	Wheat bran.	93	132	58.0	19.5	26.9	15.2	9.24
31	Wheat middlings.	24	126	27.0	20.4	13.5	7.4	7.60
32	Dark feeding flour.		98	12.2	21.6	5.7	5.4	7.04
33	Rye bran.	230	125	46.0	18.4	22.8	14.0	8.46
34	Buckwheat bran.	5	156	28.0	11.8	4.2	12.7	4.82
35	Buckwheat mid. coarse.	6	120	47.0	35.2	12.3	11.4	11.98
36	Malt sprouts.	128	120	75.1	29.7	17.4	19.9	11.68
37	Brewer's grains, wet.	158	762	12.4	6.2	4.2	.5	2.16
38	Brewer's grains, dry.	166	95	47.2	25.1	16.1	2.0	8.70
39	Gluten meal.		86	7.3	41.2	3.3	.5	11.18
40	Hominy feed.		89	22.1	12.0	9.8	4.9	4.68
41	Linseed meal, old P.		89	61.0	46.8	16.6	13.7	15.83
42	Linseed meal, new P.	20	110	62.1	45.1	17.4	13.4	15.40
43	Cotton-seed meal.	142	88	70.5	59.5	30.4	15.8	20.82
44	Cabbage.	7	856	14.1	2.8	2.2	5.2	1.48
45	Sugar beet leaves.	8	880	23.9	2.7	1.5	6.2	1.25
46	Sugar beet pulp.	16	898	5.8	.96	.2	.4	.32
47	Beet molasses.	35	207	106	14.5	.5	56.3	9.16
48	Apple pomace.	5	740	8.2	1.7	.1	.3	.26
49	Skim-milk, gravity.	96	904	7	4.9	2.1	2.0	1.74
50	Skim-milk centrif.	7	906	7.4	4.6	2.1	2.0	1.65
51	Bean straw.	6	53	69.	11.4	2.1	18.4	5.04
52	Turnips		905	8.	1.8	1.	3.9	.94

and animal excrements,—nitrogen, phosphoric acid and potash, —are not so available as they are in skillfully manufactured commercial fertilizers, yet they are usually computed at commercial prices, for there should be some convenient and uniform standard upon which to base comparisons and with which to make calculations. On the other hand, manures furnish available humus, and a mulch if they are spread upon the surface, and they also tend to increase the water-holding power of the soil, and to improve its texture or physical condition. In many cases it is believed that these benefits are a full equivalent for the less available fertilizing constituents of manures as compared with commercial fertilizers. When the soil has a reasonable amount of easily available plant-food, it is probable that such may be the case, but the ultimate welfare of plants depends so much on a healthy, vigorous start and abundant root development, that the more quickly-acting commercial fertilizers may be more valuable than the slower-acting farm manures, whenever the land is deficient in readily available plant-food. Careful observations and experiments can only determine the relative values of the constituents found in fertilizers and manures. The final productive value, as evidenced in the harvest, depends so much on the skill of the farmer, on climate, character of the plant, and rainfall, that it can never be certainly predicted whether profit or loss will result in the purchase and application of nitrogen, potash and phosphoric acid in any form. One thing is certain, that the careful husbanding of farm manures, and the application of them in reasonable quantities in almost any form, result in improved fertility and increased profits in the final income.

Bulletins Issued Since the Close of the Fiscal Year, June 30, 1898.

150. Tuberculosis in Cattle and its Control.
151. Gravity or Dilution Separators.
152. Studies in Milk Secretion.
153. Impressions of Fruit-Growing Industries.
154. Table for Computing Rations for Farm Animals. 2d Ed. revised.
155. Second Report on the San José Scale.
156. Third Report on Potato Cultnre.
157. Grape-vine Flea-beetle.
158. Source of Gas and Taint Producing Bacteria in Cheese Curd.
159. An Effort to Help the Farmer.
160. Hints on Rural School Grounds.
161. Annual Flowers.
162. The Period of Gestation in Cows.
163. Three Important Fungous Diseases of the Sugar Beet.
164. Peach Leaf-Curl.
165. Ropiness in Milk and Cream.
166. Sugar Beet Investigations for 1898.

Bulletin 155. **December, 1898.**

Cornell University Agricultural Experiment Station,

ITHACA, N. Y.

HORTICULTURAL DIVISION.

SECOND REPORT ON THE

SAN JOSÉ SCALE

WITH REMARKS ON

THE EFFECTS OF KEROSENE ON FOLIAGE.

By H. P. GOULD.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1898.

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CORNELL UNIVERSITY, ITHACA, NOV. 15, 1898.

HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

Sir:—In 1897, careful experiments were made by H. P. Gould upon methods of treating the San José scale in summer time, and the results were published in Bulletin 144 (January, 1898). It was found that a mechanical mixture of kerosene and water, 1 part of the oil to 4 parts of water, will kill the scale and not injure foliage of the plants with which we have experimented. In 1898, Mr. Gould continued the experiments, and the results, published herewith, confirm the conclusions of last year. The oil and water are mixed automatically by an attachment to the pump (see picture on title.) We are now convinced that valuable plants can be saved from an attack of the San José scale by summer treatment. However, we believe that the effort to save plants should be allowed only on stock which is permanently planted in the grounds of responsible parties, and not on stock which is to be sold.

These experiments have been made under the direction and supervision of Professor Bailey. Mr. Gould is now one of the State inspectors of nursery stock.

The report is now submitted for publication as a bulletin under Chapter 67 of the Laws of 1898.

I. P. ROBERTS,
Director.

Inspection Laws.

The San José scale has been the cause of much legistative action, fifteen States having passed laws which provide for the inspection of nursery stock and other trees, shrubs, etc., where this and other dangerously injurious insect pests and fungous diseases are likely to be found.

The States having such laws are the following: California, Colorado, Delaware, Georgia, Iowa, Kentucky, Maryland, Michigan, New Jersey, New York, North Carolina, Oregon, Pennsylvania, Virginia and Washington.

From the fact that the San José scale has become so widely distributed in the eastern States, its appearance in new and unsuspected localities may occur at almost any time, notwithstanding the existence of rigid laws and the vigilance of nursery and orchard inspectors. These inspectors are necessary means to the desired end, but it is only when the most hearty co-öperation exists on the part of the people who are concerned that the object and aim of such laws can be fully accomplished.

As a further caution, parties purchasing nursery stock should ask for a certificate of inspection, accompanying the stock when it is delivered.

The New York law is for the "prevention of disease in fruit trees and the extirpation of insect pests that infect the same." It specifics yellows, black knot and San José scale. Every infested plant is held to be a public nuisance. Persons suspecting the presence of serious diseases of fruits may apply to the commissioner of agriculture for an inspection. "Unless previously inspected by a federal officer the same year," the commissioner of agriculture shall "cause an examination to be made at least once each year prior to September first of each and every nursery or other place where trees, shrubs or plants, commonly known as nursery stock, are grown for sale," and if the stock is found to be healthy there shall be issued to the proprietor "a certificate setting forth the fact of the examination and that the stock so examined is apparently free from any and all such disease or diseases, pest or pests." Infested stock may be destroyed.

I. NOTES ON THE SAN JOSÉ SCALE.

Another season's experience has again demonstrated that the San José scale can be as easily controlled as many of the insects with which the farmer and fruit-grower are more familiar. The potato-bug has been fought for twenty years, the codlin-moth has been given annual treatments of Paris green ever since the general spraying of orchards has been practiced, yet these insects reappear in abundance every year. They and their kindred, however, cause no alarm; but if they were left unchecked in their ravages, the annual losses from them in this State would be almost inconceivable.

It may not be possible, from a practical point of view, to exterminate the scale in an infested orchard without injury to the trees any more than it is possible to exterminate the potato-bug; yet I am convinced that the same vigilant, persistent effort which controls the potato-bug, codlin-moth and other insect pests will also control the San José scale. I do not wish to minimize the danger from this insect, for it is indeed serious under conditions favorable for its development, but there has been a tendency to unduly emphasize the seriousness of the pest.

Our observations on this insect, recorded in Bulletin 144, have been continued and extended during the past season, and the conclusions at which we arrived from last season's experience have been largely corroborated.

Experiments in 1898.

A large number of small pear trees, badly infested with the San José scale, were placed at our disposal and treated with the following solutions and mixtures:

Lot No. 1. Whale-oil soap, 2 pounds to a gallon of water.
Lot No. 2. Whale-oil soap, 1 pound to a gallon of water.
Lot No. 3. Pure kerosene.
Lot No. 4. Kerosene, 20 per cent; water, 80 per cent.
Lot No. 5. Kerosene, 10 per cent; water, 90 per cent.

Lot No. 6. Kerosene, 7 per cent ; water, 93 per cent.
Lot No. 7. Quassaine, ¾ lb. to 1 qt. water.
Lot No. 8. West's Insecticide, ½ pt. to 1 gallon of water.

The first application was made June 16. The weather was clear, with no wind. Young insects had just begun to appear, a small number being found on nearly every infested tree. The second application was July 1. The weather was clear, very hot and no wind on this latter date.

The following notes were taken on the results of the first application : Mixtures No. 3 and 4 seem to be the only ones which have had much effect. On the trees thus treated, there are very few young insects to be found, indicating that nearly all of the mature insects have been killed by the first applications of clear kerosene and the mixture of 20 per cent kerosene and 80 per cent water. There are apparently as many young insects on all trees sprayed with the other solutions and mixtures as there are on the trees which have not been sprayed. The presence of so many young insects on these trees would seem to indicate that the materials used had not been effective in destroying the mature insects. It should be stated in this connection, however, that the physical condition of the whale-oil soap used at the time of the first application, was not satisfactory.*

The third and last application was made July 19. The weather was cloudy and very "muggy." At the time of making this application, the following conditions, results of the first two applications, were noted :

No. 1. Foliage slightly injured ; trees practically free from young insects.
No. 2. Foliage slightly injured ; a few young insects found.
No. 3. About 10 per cent of foliage injured ; insects apparently all killed.
No. 4. Practically no injury to foliage ; no young insects to be found.
No. 5. Foliage uninjured ; young insects numerous.
No. 6. Foliage uninjured ; young insects numerous.
No. 7. 50 per cent of foliage injured ; young insects numerous, but mature ones show some effect of treatment.
No. 8. 75 per cent of foliage injured ; but few young insects alive.

Results of sprays.—It was intended after the application on July 19, to

---

*The whale-oil soap solutions in Nos. 1 and 2 were applied with a brush and this fact doubtless accounts for the slight injury to the foliage. Only small quantities of the solution came in contact with the leaves. The soap solution used at this time, instead of being of uniform consistency, was of a granular nature ; that is, there seemed to be a very thin liquid (probably water) in which was a coarse precipitate. In this condition it was impossible to apply it thoroughly, even with a brush. As this difficulty had not been experienced before in using other lots of the same brand of soap, I wrote to the manufacturers in regard to it. In their reply they suggested that better results might be obtained if the soap were dissolved in moderately hot water and agitated while cooling. This caution was followed in preparing the soap used in later applications, and none of the earlier difficulty was experienced.

allow the trees under experiment to remain undisturbed for the remainder of the season and so watch the ultimate results of the applications, but owing to circumstances it became necessary to make the final records about the middle of August, as follows:

No. 1. Insects apparently all dead.
No. 2. A few insects alive.
No. 3. Insects apparently all dead.
No. 4. Insects apparently all dead.
No. 5. Insects apparently all dead.
No. 6. A few insects alive.
No. 7. A few insects alive.
No. 8. Insects apparently all dead.

The condition of the foliage on all the trees remained essentially the same as it was on July 19, when the notes recorded above were taken.

Effects of whale-oil soap.—In the light of these experiments, several facts are conspicuous. It will be noted that the first application of whale-oil soap had little effect on the scale. From the results of the later applications, it is evident that the ineffectiveness was due in part, if not entirely, to the poor physical condition of the soap solution. In the final examination of the trees treated with whale-oil soap, the fact was again emphasized that a solution weaker than two pounds to a gallon of water cannot be relied upon to kill the scale.

Effects of kerosene.—Four different strengths of kerosene were used in these experiments: pure, 20 per cent, 10 per cent and 7 per cent. The pure kerosene was the only strength which injured the foliage to any appreciable extent, and in this case the injury was not sufficient to interfere with the normal activities of the trees. From the fact, however, that a 20 per cent mixture of kerosene and water gave equally as good results as clear kerosene in killing the scale, there seems to be no reason for using a stronger mixture than this. This mixture (20 per cent,) has in no case, under my observation, injured the foliage.

The mixtures containing the smaller percentages of kerosene were less satisfactory, though the final results of the 10 per cent mixture indicate that good returns may result from the use of this strength. A 7 per cent mixture, or 1 to 15, is evidently too weak to be effective, as live scales were found on the trees so treated during all the time they were under observation.

The kerosene and water mixtures were applied by means of a pump having a kerosene attachment, thus using the ingredients in the form of a mechanical mixture. Several pumps of this type are now on the market.

As a further suggestion as to the use of pure kerosene, a word of caution may be given. While no serious results followed the use of it in the cases above noted, very conflicting results have been obtained by different experimenters, and by the same experimenters at different times. In many cases no apparent harm has followed its use, while in others, for no obvious

reason, the trees have been killed. Probably the best time to use kerosene in any strength is on a bright sunny day when the conditions favor a rapid evaporation of the kerosene. Pure kerosene should not be used without an appreciation of the fact that the results may prove fatal to the plants treated with it.

Of the different solutions and mixtures used in this series of experiments, it is evident that, all things considered, No. 4 or 20 per cent kerosene and 80 per cent water, is the most satisfactory. While this was fully effective in destroying the scales, the foliage remained in good condition. This result corroborates our experience (in Bulletin 144) of last year. Some of the stock which was treated with the 20 per cent mixture was examined by Mr. Slingerland, who pronounced all the scales to be dead.

CONCLUSIONS FROM OUR EXPERIENCE.

Practicability of spraying.—The practicability of spraying for San José scale will depend entirely upon conditions. In the case of fruit trees or ornamentals, permanently set, which have not already become weakened from the effects of the scale, it would seem, in the light of the evidence at hand, to be an entirely feasible operation and if thoroughly done, there can be little doubt as to its effectiveness; but spraying cannot be recommended for nursery stock. When the trees are so close together as they are in the nursery, it is impossible to spray with sufficient thoroughness to insure complete success, and the possibility of distributing the scale on trees thus sprayed becomes too great to warrant such a method of treatment.

When to spray.—From the fact that the scales are probably more susceptible to the action of insecticides during the period of activity than they are during the winter months, it follows that a weaker insecticide can be used in the summer than during the winter; and so far as the use of kerosene is concerned, the evidence at hand seems to show that plant life is little, if any, more liable to injury from it when in an active state of growth than when dormant. Accordingly, the summer season would seem to be the preferable time to spray if kerosene in any form or strength be used. Professor J. B. Smith recommends the use of pure kerosene during the middle of a clear sunshiny day in Sep-

tember. In our own experience we have obtained satisfactory results by using kerosene in the spring or early summer as soon as the young insects began to appear.

In using whale-oil soap, the nature of the case demands that it be applied only when the plants to be treated are dormant. Since it must be used at the rate of two pounds to a gallon of water in order to destroy the scale, and at this strength it is destructive to the foliage, a summer treatment with whale-oil soap is out of the question unless it be applied only to the trunks and larger limbs of infested trees and shrubs.

FUMIGATING.

As a method of treating infested nursery stock, fumigating with hydrocyanic acid gas is doubtless the most satisfactory and effective treatment which has been extensively used. The value of this treatment was recognized in California some years ago, but for various reasons it has not been generally used in the East. However, there seems to be no adequate reason why it should not prove as effective here as in the West. Probably the most extensive use of the gas treatment in the eastern States has been in the experiments of Johnson, of Maryland. In his recent report* there is detailed a long list of experiments in which is seemingly proved the adaptability of this method of treatment for eastern as well as for western conditions. The most of Johnson's work, however, was in bearing orchards where tents were used for covering the trees during treatment.

The chemicals used by him in giving the gas treatment are approximately as follows:

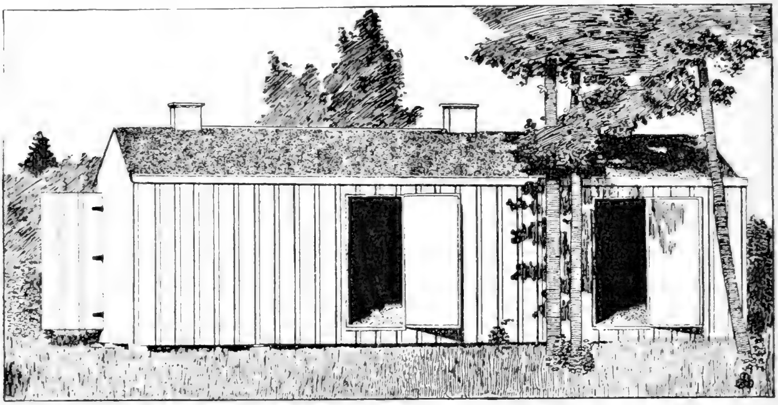
Fused cyanide of potassium, 98 per cent pure...	1 oz. by weight
Sulfuric acid	1 ¼ oz. by measure
Water	2 oz. by measure

The above quantities of material are sufficient for 100 cubic feet of space.

In fumigating nursery stock in small quantities, a large box which can be made perfectly air-tight is convenient. The stock is first placed in the box, then an earthen or glass vessel placed near the center of the box, the cubical contents of which has been previously estimated. The chemicals are then weighed out

*Bulletin 57, Maryland Experiment Station.

in proportion to the size of the box, the above mentioned amounts being used for every hundred cubic feet of contents. The sulfuric acid should be put in the vessel, the water added, and last of all the cyanide is dropped in. If the latter is carried in a paper bag, the bag may also be dropped into the diluted sulfuric acid, and in this way the danger of handling is somewhat reduced. As soon as the cyanide is put in the acid, the box should be quickly closed and the stock allowed to remain at least thirty minutes.



8. *Fumigating house. Adapted from Johnson.*

When large amounts of nursery stock are to be fumigated, a small building specially constructed for the purpose will be more satisfactory. Such buildings are in common use in Maryland, where all stock handled by nurserymen is required by law to be given the gas treatment.

A fumigating house.—A building similar to the one in question is illustrated by Johnson and described as follows : "It is 32x16x8 feet with a roof pitch of two feet, and is divided into two rooms about 15x14x7 feet and two smaller rooms 4x5x7 feet constructed as follows :

"First, a good substantial frame is built which is covered outside with 1¼ inch 12 inch Virginia pine boards, and ½x4 inch batting. The interior is first lined with two-ply cyclone paper and then with 4 inch flooring. The partitions and floors are also double with paper between. The roof is covered with heavy roofing paper, tarred and graveled. The doors are 6½ x3 feet (3½ would be better), made double, refrigerater style, and hung with three heavy strap-iron hinges, and held in place when closed with two

bolts. At the top of each large room on the opposite side there is a door 3x2½ feet for ventilating purposes. There is also a flue opening between the rooms as shown in the illustration, which can be uncapped when it is desired to air the house." (See Fig. 7.)

Johnson estimates that a house the size of the one described is large enough for parties handling a million or more trees annually.

The advantage of having a double house or room with a partion in it lies in the fact that when there are large quantities of stock to be fumigated, one side or one room can be filled while the treatment, which should continue for at least a half hour, is being applied to the other, thus greatly facilitating the work.

In using such a house as this, one would proceed in essentially the same manner as described for using a fumigating box. After the doors have been opened, following a fumigation, the house should be allowed to air for at least ten minutes before an attendant attempts to enter.

Caution.—In handling sulfuric acid and cyanide of potassium, all possible care must be taken. The former will destroy clothing if it comes in contact with it, and wounds caused by it are very painful and slow to heal. *The cyanide of potassium is one of the most deadly known poisons.* After the fumigating box or house is opened after being used, it should be very thoroughly aired before the attendants approach near enough to inhale any of the gas, as serious results will follow if this precaution is not taken. As cyanide of potassium will absorb moisture if exposed to the air, it should be kept in tightly closed jars or cans.

Conclusion.—In the work of Johnson, this method of treating bearing trees has been proved to be of practical importance when properly managed. In such operations, the trees are covered during treatment by tents constructed for the purpose, and where one has a large number of infested trees, it may be more satisfactory, in the end, to have such tents made and apply this treatment rather than to spray.

SUMMARY.

1. With the exception of the pure kerosene and the 20 per cent mixture, the first applications of the various insecticides seemed to be mostly ineffective. The poor physical condition of the whale-oil soap solution may account for its not being more satisfactory.

2. In the final results, live scales were found on trees treated with whale-oil soap, one and one-half pounds to a gallon of water; a 1 to 15 mixture of kerosene and water; and quassaine. The insects on all the trees treated with the other materials seemed to be killed but with various effects on the foliage.

3. A solution of whale-oil soap weaker than two pounds to a gallon of water cannot be relied on to kill the scale.

4. Of the different kerosene mixtures, the 20 per cent or 1 to 4 mixture gave the most satisfactory results. A 10 per cent mixture may be effective but should not be relied on for the best results.

5. The practicability of spraying for the San José scale is dependent upon conditions. Nursery stock, if badly infested, should usually be burned.

6. Probably the most satisfactory time to spray for the scale is during its active stage; that is, during the summer and early fall months.

7. Fumigating with hydrocyanic acid gas may doubtless be used successfully in many cases.

9. *San José scale, natural size.*

10. *Oyster-shell bark-louse. Nat. size. Often mistaken for the scale.*

8. A building made especially for the purpose is convenient if large quantities of nursery stock are to be treated.

9. As potassium cyanide is a most deadly poison, also the gas generated in fumigating, great care must be taken in using and handling it. Air the room thoroughly before entering it.

II. EFFECTS OF KEROSENE ON PEACH AND APPLE TREES.

Although the value of kerosene in combating sucking insects was recognized in the early history of spraying, yet it is only within the past few years that it has been used to any extent in any other form than as an emulsion with soap. But with the advent of the San José scale in such force in the East, experimenters began to turn their attention to kerosene in other forms, and as a result many references to the effects of kerosene have appeared in horticultural literature during the past few years. And yet there is much to learn concerning kerosene and its effects on plant life. From the fact that the results have been so conflicting without any apparent reason, the use of kerosene is an uncertain practice. It is generally conceded by those who have had much experience that the conditions of the weather have a marked influence in determining its effects; that if applied in bright sunny weather,—a condition which favors the rapid evaporation of the oil,—the liability to injury is greatly reduced in comparison with applications made in cloudy weather.

With respect to the effect of the 20 per cent mixture of kerosene with water on the buds of Cornus and Pyrus referred to in Bulletin 144, it may be said that they did not suffer in the least. The trees and shrubs sprayed with this strength of kerosene, a year ago, made an excellent growth the past season and are now in good condition. Several months after the Cornus bushes were sprayed, the bark, in some instances, indicated some injury, but it has not proved to be of a serious nature. I think this injury might have been avoided if the climatic conditions had been regarded when the spraying was done.

It was with the hope of throwing some light on the effects of kerosene and of determining under what conditions it is possible

to use it with impunity that a series of experiments was begun during the winter of 1897–8. The trees used for this work were young peaches and apples.

Kerosene in four strengths was used ; pure, 50, 40 and 20 per cent.

The first series of trees was sprayed February 7, and others March 7, April 13, May 3 ; and the final notes were made May 20 and July 8. The character of the weather was carefully noted at each treatment. In applying the kerosene to the trees, a Stott's nozzle, which makes a very fine spray, was used, and while the trees were thoroughly sprayed, care was taken not to apply more of the various strengths of kerosene than was required to thoroughly moisten the surfaces.

It is not necessary to repeat all the details of the experiment, but to give only the summary conclusions.

From the results of the experiment, it was evident that kerosene should be used with caution, especially on peach trees. While in no case were any apple trees greatly injured, several peaches suffered very serious injury. Any mixture of kerosene stronger than 20 per cent, applied to peach trees, even when dormant, is likely to affect the tree injuriously. In some cases under observation, it was noted that a 50 per cent mixture was more disastrous than when used undiluted.

It seems probable that clear kerosene may be used on apple trees without serious results, although it is not unlikely that trees so treated are in some instances more or less weakened. Any strengths weaker than 50 per cent seem to have little, if any, injurious effect on apple trees.

Again, in the light of the data at hand, the commonly accepted notion that kerosene applied on a cloudy day is more likely to injure the plant than if applied on a clear sunshiny day, is corrobrated. With only one exception in the case at hand, did this result otherwise.

It is not unlikely that the manner in which the kerosene is applied may have material effect upon the results. If the spray is coarse, so that in applying it the trees become drenched with oil and it forms in drops on the tips of the leaves, the danger is doubtless much greater than when a very fine spray is used and

the foliage and branches are merely moistened. In the latter case the evaporation is rapid, and this seems to be one of the essential features in avoiding the injurious effects of kerosene.

The results of our experience in the use of kerosene are not unlike those of others. Experimenters have recorded very conflicting results in their experience with pure oil, in some instances very little harm coming from its use, while in other and similar cases, without apparent cause or reason, very serious results have occurred.

Why such conflicting results should occur is difficult to explain, but it seems not unlikely that it may be due to the individual variation of the trees or plants treated.

From our study of the subject we draw the following

SUMMARY.

1. Pure kerosene is likely to seriously injure peach trees even when they are perfectly dormant.

2. A 20 per cent mixture of kerosene can probably be safely used on the peach at any time, but a stronger mixture cannot always be so applied.

3. Apple trees do not appear to be as susceptible to the action of kerosene as peaches. In some instances clear kerosene did not harm them.

4. There seems to be little, if any danger, to apple trees from a mixture containing 50 per cent or less of kerosene.

5. Very conflicting results are often obtained from the use of kerosene.

6. Kerosene is especially likely to cause injury if applied on other than a bright sunny day.

7. In our experience, a 20 per cent solution (1 part oil to 4 parts water) is harmless to plants and destructive to insects, even to the San José scale.

H. P. GOULD.

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153. Impressions of Fruit-Growing Industries.
154. Table for Computing Rations for Farm Animals.
155. Second Report on the San José Scale.

Bulletin 156. **December, 1898.**

Cornell University Agricultural Experiment Station,

ITHACA, N. Y.

AGRICULTURAL DIVISION.

Third Report on Potato Culture.

By I. P. ROBERTS and L. A. CLINTON.

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THIRD REPORT ON POTATO CULTURE.

Conclusions Based Upon Experiments in Potato Culture During Four Years.

1. The average yield of potatoes throughout the state is not more than one-half what it should be and what it would be were better methods practiced.

2. All soils of ordinary fertility contain sufficient potential plant food to produce abundant crops. By tillage, and drainage if necessary, a part of this potential plant food can be made available for the use of plants.

3. Early planting of potatoes and frequent tillage to conserve moisture will ordinarily give best results.

4. Early planting necessitates vigorous spraying with Bordeaux mixture and Paris green to protect the foliage from blight and beetles.

5. Success with potatoes depends largely upon the preparation given the soil before the potatoes are planted. Plowing should be deep, and at the time of planting, soil should be mellow and loose.

6. On soils which are likely to be affected seriously by droughts, it is especially important that the potatoes be planted early and deep and the tillage should be frequent and level.

7. On soils which are not well drained, either naturally or artificially, and on clay or clay loam soils, potatoes may be planted somewhat shallow and slight hilling may be practiced with benefit.

8. Harrowing the land after the potatoes were planted and before the plants appeared produced marked beneficial results.

9. From six to seven cultivations have given best yields.

Potato Experiments in 1898.

For four years the experiments with potatoes have been continued. In 1895 an experiment was planned, the object of which

was to determine something of the possibilities of the soil when superior methods of tillage were practiced. A study of the statistics of crop production in New York and other states revealed the fact that something was radically wrong with the soil or with the methods being pursued. The average yield of the ordinary farm crops had fallen so low that in many cases actual loss resulted in their production. This condition prevailing while the soil was yet comparatively new, led to the belief that tillage was being neglected. The experiments were planned to learn what could be accomplished by superior tillage and care. The results of these experiments for previous years have been recorded in bulletins 130 and 140 of this station. While the results for 1898 do not differ materially from the results heretofore secured, yet it seems wise to publish the same.

Details of experiment.—The land selected for the experiment was a portion of the series of plats upon which the experiments had been conducted in previous years. The soil is gravelly and porous and especially subject to injurious effects from droughts. The potato crop grown this year is the fifth crop removed from the land since any fertilizer or manure has been applied. The soil is beginning to show a deficiency of humus owing to the intensive culture which has been given and the slight returns of organic matter. While cover crops of crimson clover, wheat or rye have been used, yet necessarily the growth has been restricted and the amount available to plow under in the spring has been small. The result of this deficiency of humus is shown in the tendency of the soil to become hard and compact under the effects of beating rains. In order to keep a soil permanently in good physical condition, it is absolutely necessary that organic matter be returned in some way either by green manuring or the use of barn manures.

Previous treatment of the soil.—The plats entering into the experiment have been cropped heavily for five years since any manures were applied with the exceptions noted below. In the winter of 1893–4, about ten tons of mixed barn manure were applied per acre. In 1894 all plats were planted to corn which was one of the regular crops in the four years rotation. Previous to 1894 the rotation which had been practiced was

1. Wheat.
2. Clover and timothy.
3. Corn.
4. Oats.

The crops which have been produced upon each plat since and including 1894 are shown by the accompanying table :

Plat No.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.	31.	32.
Crop of 1894	Corn	Corn	Corn	Corn	Corn	Corn	Corn	Corn	Corn	Corn	Corn	Corn
Crop of 1895	Potatoes	Potatoes	Potatoes	Potatoes	Potatoes	Potatoes	Potatoes	Potatoes	Used for roadway	Potatoes	Corn	Corn
Crop of 1896	Corn	Corn	Corn	Corn	Corn	Corn	Corn	Corn	Potatoes fertil-ized	Potatoes fertil-ized	Potatoes	Potatoes
Crop of 1897	Oats	Oats	Oats	Oats	Oats and peas	Oats and barley	Peas	Barley	Barley	Oats	Oats	Oats and peas
Crop of 1898	Potatoes	Potatoes	Potatoes	Potatoes	Potatoes	Potatoes	Potatoes	Potatoes	Potatoes	Potatoes	Potatoes	Potatoes

While it will be seen that all plats have not received the same treatment each year, yet the various plats can be compared with reference to their previous treatment.

In all cases after the crop was removed the land was plowed and seeded either to crimson clover, or rye, or wheat which was allowed to serve as a cover crop during the winter and was plowed under in the spring. Thus the land has been thoroughly plowed from two to three times each year.

Record of the potato crop for 1898.—In the spring, as early as the conditions of the soil would permit, the land was plowed to a depth of about ten inches. Shortly before the time for planting, the land was re-plowed with the gang plow, the furrow being

turned to a depth of about four inches. The harrow was then used and the surface thoroughly pulverized and fined. Rows were marked off at a distance of 40 inches apart and the furrows for the potatoes were opened with a common shovel plow to a depth of about five inches.

The "seed" was from first-class stock, only large, marketable potatoes being used. These were cut into pieces containing from one to three eyes, about two strong eyes to the piece being what was desired. The pieces were dropped in the furrows directly after the furrows had been opened, one piece being put in a place and at distances fourteen inches apart in the row. The shovel plow was again used and a furrow was opened in the middle of the space left when the first furrows were opened. This second use of the shovel plow served to cover the potatoes, the earth being ridged up directly over the potato row. (See frontispiece which is from photograph). The planting was done on May 10. The soil was tnen left undisturbed until May 28. The ridges which were left over the seed potatoes covered them to a depth of about eight inches. By May 28 the weed seeds which were in the surface soil had germinated and the whole surface was covered with tiny weeds. A spike tooth hrrrow was fitted with a piece of 2x4 scantling placed diagonally across underneath the frame and held in place by the harrow teeth. The harrow thus rigged was used upon the potato plats, being first run lengthwise of the rows and then crosswise. The weight of the driver upon the harrow was necessary in order to make it do the leveling as required. The benefit derived from this treatment was very marked. All weeds were destroyed, the suiface crust was broken, all clods and stones were removed from above the row and deposited in the center of the space between rows, the surface was leveled and in every way the conditions were made favorable for the rapid growth of the potatoes, and they appeared above ground in three or four days.

The treatment which the various plats received during the season and the yield from each plat is shown by the following tabular statement.

RECORDS OF POTATO PLATS, 1898.

Plat No.	Date planted.	Variety of potatoes.	No. of cultures.	No. of spraying.	Date of digging.	Yield per plat. Pounds.	Yield per acre. Bushels.
21	May 10	Endurance.	6 level	7	Oct. 18	1,196	398.6
22	"	Carman No. 3.	6 "	7	" 18	1,034.5	344.8
23	"	" "	3 "	7	" 18	910	303.3
24	"	" "	3 "	7	" 17	1,020	340
25	"	" "	3 hilled	7	" 17	982.5	327.5
26	"	" "	6 level	7	Sept. 29	931.5	310.5
27	"	" "	3 "	7	" 29	809	269.6
28	"	" "	3 "	7	" 29	809.5	269.8
29	"	" "	6 "	7	" 29	610	213.3
30	"	" "	6 "	0	" 29	618.5	206.1
31	"	Rose of Sharon	6 "	7	" 29	356	118.6
32	"	Endurance.	6 "	0	" 29	696	232

Spraying operations.—Early in the growth of the potatoes spraying became necessary. In addition to the Colorado potato beetle (Doryphora decemlineata), the leaf-flee-beetle (Crepidodera cucumeris) early began its depredations. Bordeaux mixture and Paris green used freely served to check both insects. Several farmers have informed us that the Bordeaux mixture has failed with them to check the work of the leaf-flee-beetles, but with us for three years in succession it has proven effective in checking, although it has not entirely driven them away. Bordeaux mixture made and tested with the ferrocyanide of potassium proved very satisfactory.

Directions for making Bordeaux mixture.—Directions were given in Bulletin 140 for making Bordeaux mixture. We have found that the ferrocyanide of potassium test is much simpler and so the following directions are given:

Into a barrel of water suspend a gunny sack or other porous bag, containing two pounds of copper sulfate for every gallon of water in the barrel. If this is suspended near the surface of the water at night it will all be in solution by morning and ready for use. Into a water tight box or other open receptacle place some fresh burned caustic lime, the amount to be determined somewhat by the amount of spraying to be done, but from 40 to 50 pounds of lime can be easily slaked at one time. Add sufficient water to

thoroughly slake all the lime and keep well stirred so that the water may come in contact with all particles. This thorough stirring is important and the lime should be carefully watched and stirred for several minutes or otherwise it is likely to become dry and hard. After the lime is all slaked, cover it over with water and it is then ready for use and may be kept for any length of time desired if it is always kept covered with water. Ferrocyanide of potassium may be purchased from the drug store, and comes as a solid. One ounce of ferrocyanide of potassium dissolved in one ounce of water will be sufficient for testing many barrels of the Bordeaux mixture. When it is desired to begin spraying, there should be provided two empty barrels. Into one barrel dip three gallons of the copper sulfate solution after it has been *thoroughly* stirred. This will provide the six pounds of copper sulfate in case two pounds were dissolved per gallon of water and will be sufficient for making one barrel, or 45 gallons of Bordeaux mixture. Dilute the three gallons with ten or more gallons of water.

From the lime box dip from five to ten pounds of slaked lime into the empty barrel. Add water and stir thoroughly until the milk of lime is produced, after which dilute with some ten gallons more of water. Pour the milk of lime thus diluted through a sieve into the dilute copper sulfate solution. The quantity of lime to be added to the copper sulfate is to be determined by the ferrocyanide of potassium test. After adding a small amount of the milk of lime to the copper sulfate solution, add to the mixture a drop of ferrocyanide of potassium. If a brick red color is produced where the drop strikes, it indicates that more lime is needed. Continue adding the milk of lime until no reddish color will be produced when the ferrocyanide of potassium is used. A few trials will enable one to judge very accurately as to the amount of lime required. A little surplus lime will do no harm.

If Paris green is to be used it should now be added. Take 4 ounces of Paris green and place it in a dish and add water just sufficient to make a paste, and stir thoroughly until a homogeneous mixture is formed. Pour this paste into the mixture of lime and copper sulfate and stir vigorously.

Pour the lime and copper sulfate mixture into the spray barrel,

which should have a capacity of 45 to 50 gallons, and fill the barrel with water. If there is no agitator in connection with the pump, the mixture should be frequently stirred while being applied.

The directions given above were followed during the past year with good results. While the check plat, No. 30, which was not sprayed does not show much falling off in yield over plat. No. 29, yet we believe that as a matter of policy, spraying should be practiced. When the blight does appear it comes so suddenly and usually with such virulence that nothing can then be done to prevent its ravages. As a preventive measure spraying with Bordeaux mixture should become the general practice instead of the exception.

The July drought.—During July there prevailed a most severe drought. The amount of moisture on some of the plats was reduced to four per cent as determined by samples taken one foot deep. This condition threatened to seriously injure the crop and no doubt did effect it to some extent.

The soil having been thoroughly prepared and the potatoes covered deeply, and the surface kept loose, the plants were able to survive and produce a very satisfactory crop. We learn that some farmers who followed the directions given in the previous bulletins met with failure of the potato crop owing to the July drought. The potatoes were planted at such a time that the new tubers were just setting at the time of the drought, with the result that they failed to set fully. Had they been planted earlier or later the probability is that a better crop would have resulted.

The frequency of droughts enforces the importance of having a soil well supplied with humus, early plowing, deep planting of the potatoes, especially on porous, leachy soils, and frequent tillage.

LESSONS DRAWN FROM THE EXPERIMENTAL POTATO PLATS IN 1898.

A study of the table giving yield of plats from 21 to 29 inclusive will show that there is not a wide range in yield from those plats but that all are well above the average. The extra tillage

does not seem to have produced the marked results that were shown in the previous experiments and this was probably due to excessive droughts preceded and followed by excessive rains. When a study is made of the table giving yields, a study should also be made of the table showing what crops have been produced on each plat during the past five years. All of these crops have been well above the average and the annual drain upon the soil has been greater than upon ordinary soils. To explain the uniformly high yield we must then make a study of the treatment which all plats have received. It is probable that frequent and deep plowing has done much to bring and keep the land productive. So far as the plowing is concerned all plats have received the same treatment. The land has been turned from two to three times each year, and the pulverizing which has resulted therefrom has liberated sufficient plant food to mature large crops. In addition to the plowing the land has been frequently harrowed and cultivated and the intensive culture which has been given has liberated all the plant food that could be used by the growing crops with the amount of moisture that was present.

Plats 30 and 32 were not sprayed. Paris green was applied with plaster to kill the Colorado potato beetles. The potatoes grown on Plat 32 were the same variety as those grown upon Plat 21 which was kept well sprayed. It is not probable that the spraying alone was responsible for the wide difference in yield as the land becomes more gravelly in texture and hence more leachy as it approaches Plat 32. The variety, Mill's Endurance, is said to be blight proof and it does seem to possess to a remarkable degree qualities which enable it to resist blight. Plat 32, though it was not sprayed, remained in fairly good condition until killed by frost. On Plat 21, the same variety which was sprayed with Bordeaux mixture, the foliage remained remarkably healthy and vigorous, and even though the variety seems to be exceedingly hardy, yet the effect of the spraying was very marked.

On Plat 31 the variety, Rose of Sharon, seemed utterly unable to resist the blight. It was sprayed seven times with Bordeaux mixture and finally succumbed to blight in the early part of the season. The varieties which have with us proven most satisfac-

tory are Carman No. 3, Rural New Yorker No. 2, and Mill's Endurance.

Field potatoes.—An area of 1.01 acres, the larger part of which had been devoted for several years to the raising of mangold wurzels, was planted to potatoes May 28. The land was fitted similarly to the manner described on the plats. Part of this land had been fertilized for several years with annual applications of barn manures, and had been brought into good condition.

Preparation of the seed.—About three weeks before the potatoes were planted the seed was cut. It was the purpose at the time of cutting the seed to plant the potatoes within a few days, but almost continuous rains delayed the work until the end of May. The potatoes which had been so long cut had been very much weakened in vitality, having heated and moulded somewhat. They were planted, however, and the stand secured was very poor, a considerahle portion of the field having to be replanted.

The furrows for the potatoes were opened with a double mold-board plow, the rows forty inches apart and the potatoes were dropped one piece in a place at distances of 14 to 18 inches apart. The double mold-board plow was then used in covering the potatoes and the soil was left ridged up above the rows. As a portion of the field was a clay loam soil and rather wet at the time of planting, the harrow was used within one week and the ridges were leveled down and clods were pulverized before they became too hard and dry to crush easily. The soil was warm and moist and the potatoes came up quickly. About the time they were breaking through the surface the weeder was used with good results. It broke the crust and destroyed weeds that could not be reached with a cultivator. Bordeaux mixture with Paris green was used five times and five cultivations were given. The yield from the field containing 1.01 acres was 216 bushels, or a yield of 214 bushels per acre.

Lessons drawn from the acre of potatoes.—Seed should not be cut for any considerable period before planting. If it becomes necessary to delay planting for some considerable time after potatoes are cut, the cut pieces should be dusted with plaster and spread out in a moderately moist, cool place. At least they should not

be allowed to heat, neither must they be allowed to become dry.

If planting is done very early in the spring the ridges may be permitted to remain for ten days to two weeks before harrowing down. If planting is done somewhat late the ridges should be harrowed within one week after planting. In the case of the early planting there is usually enough moisture present so that the ridging may temporarily prove a benefit by enabling the soil to become warm. In the case of late planting all the moisture should be conserved, and this is best done by leveling the ridges. Where the soil is naturally too wet the ridges may be beneficial in that they hasten evaporation and the consequent drying of the soil.

Several causes contributed to the low yield on the acre field, chief among which were seed which had become weakened in vitality thus necessitating replanting, late planting, excessive drought in July, followed by excessive rains. While the land had been receiving fairly liberal applications of manure and was in a good state of fertility, yet the causes above mentioned conspired to produce but little more than half the crop which should have been produced under favorable conditions.

I. P. ROBERTS,
L. A. CLINTON.

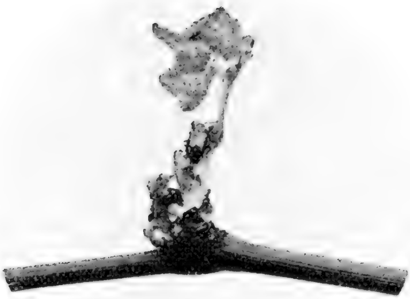
Bulletin 157. December, 1898.

Cornell University Agricultural Experiment Station.

ITHACA, N. Y.

ENTOMOLOGICAL DIVISION.

THE GRAPE-VINE FLEA-BEETLE.



BY M. V. SLINGERLAND.

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Cornell University, Ithaca, N. Y., Dec. 8th, 1898.

The Honorable Commissioner of Agriculture,

Albany, N. Y.

Sir:—This bulletin embraces the results of long investigation and observation of the grape-vine flea-beetle and is submitted for publication under Chapter 67 of the Laws of 1898.

The difficulties of combating this pest of the vineyard have heretofore appeared to be insurmountable. The life-history and habits of the beetle have been discovered, and the results of numerous experiments indicate that it is not more difficult to destroy than many other pests.

The bulletin certainly emphasizes the need of being alert and observing. The mistake in the past seems to have been that the enemy was allowed to do its work before an effort was made to destroy it.

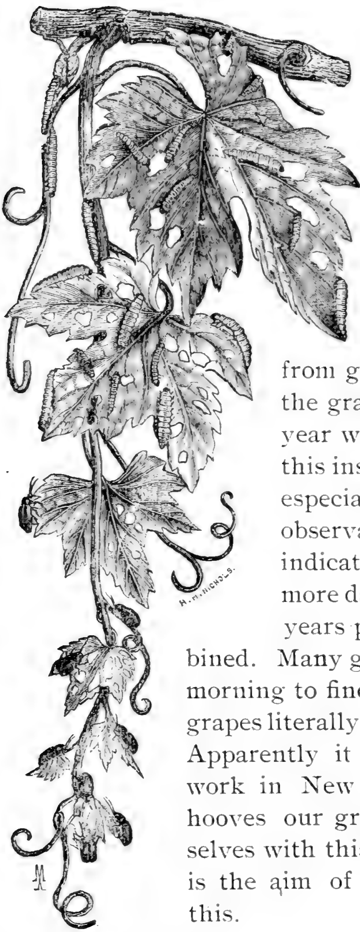
This bulletin will commend itself, we believe, to the grape-growers of the country not only because of its completeness and of the care which has been exercised in the work necessary to secure the facts embodied in the publication, but because of its practical value to the grape industry.

I. P. Roberts,
Director.

THE GRAPE-VINE FLEA-BEETLE.

Haltica chalybea Illiger.

Order COLEOPTERA; family CHRYSOMELIDÆ.



11.—*Grape-vine Flea-beetles and their grubs at work, natural size.*

In general, insect enemies are not a serious drawback to grape-growing in New York; the vineyardist usually suffers much less from their ravages than the orchardist. While most of the common injurious insect pests of the grape-vine are to be found in New York vineyards, by far the larger proportion of complaints of insect ravages which reach us from grape-growers refer to the work of the grape-vine flea-beetle. Almost every year we receive several inquiries about this insect, and the complaints have been especially numerous during 1898. Our observations and correspondence would indicate that this flea-beetle has done more damage in our vineyards for several years past than all other insect foes combined. Many grape-growers have awakened some morning to find all of their prospective crop of grapes literally "nipped in the bud" by this pest. Apparently it is the worst insect pest now at work in New York vineyards. Hence, it behooves our grape-growers to familiarize themselves with this flea-beetle and its life-story. It is the aim of this bulletin to help you to do this.

THE HISTORY AND DISTRIBUTION OF THE INSECT.

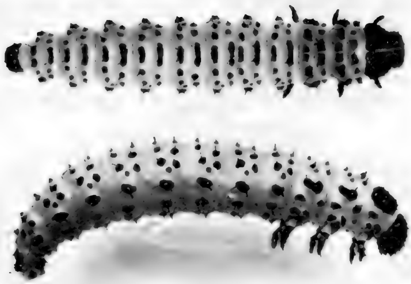
Nearly a century ago specimens of this flea-beetle from Georgia and Pennsylvania found their way into European collections, and in 1807 it was described and given its scientific name by Illiger, a German. The year previously it had been listed in America in a published catalogue of the insects of Pennsylvania (see the first reference in the Bibliography). In 1824 the insect was again described under a different name by our famous American coleopterist, Le Conte. He states that it occurred from New York to Georgia ; thus the insect has been a native of our state for at least 75 years.

Apparently nothing was known of the habits of this flea-beetle until about a quarter of a century after it was first found and described. In 1834, David Thomas recorded that it appeared on grape-vines in considerable numbers in Cayuga county, N. Y., near Philadelphia, Pa., and in New Haven, Conn., and vicinity, in the spring of 1831 ; in 1830, Thomas saw the grubs at work on grape leaves but did not recognize them as belonging to this insect until he raised the adult insect in 1832.

The literature during the next thirty years contains several records of injuries by this flea-beetle in different parts of the country. In 1860 it was very injurious in Delaware, and also during the next three years in various parts of New York ; as early as 1863 it was reported as injurious as far west as Wisconsin. By 1870 its life-history was fairly well understood by entomologists, and most subsequent accounts of it, except Comstock's in 1880, are compilations.

During the past thirty years this flea-beetle has seriously damaged vineyards in widely separate portions of the country every year, and it has been discussed by nearly all the prominent writers upon injurious insects. It is a native of North America and occurs throughout the eastern half of the United States from New England southward to southern Florida, and westward through Canada and southern Michigan to southern Minnesota, thence southward to eastern and southern Texas ; its western-

12.—*The Grape-vine Flea-Beetle, natural size and enlarged.* a, *hind leg of the beetle much enlarged.*



13.—*Dorsal and lateral views of a grub of the Grape-vine Flea-beetle, enlarged.*

14.—*a, pupa of the Grape-vine Flea-beetle. b, cast-skin of one of the grubs.*

most recorded limits are eastern Kansas and eastern Nebraska*. The insect doubtless occurs in injurious numbers in most of the grape-growing regions within the boundaries of this vast territory. Judging from the number of reports of its ravages which have reached us during the past few years from the great grape-growing sections of central and western New York, this flea-beetle must be present in alarming numbers in these regions and is apparently on the increase.

It doubtless occurs in all parts of New York where grapes grow, but its injuries are usually confined to a limited locality each year. We have no report of its having been destructive over an extensive area, even in the great grape-growing districts of the state; but often reports reach us where a few vines in a village yard or a certain block of vines in a large vineyard are stripped of their buds by the insect, while a neighbor's vines a few rods away suffer very little, if any, damage. Thus, although the insect is generally distributed, its occurrence in injurious numbers is usually over limited areas in New York state.

DESCRIPTION OF THE INSECT.

This insect enemy of the grape-vine is one of that group of leaf-feeding beetles known as the flea-beetles. The thighs of the hind legs of these beetles are much thickened (Fig. 12 *a*), thus fitting them for jumping quickly like fleas. The grape-vine flea-beetle is a small, dark, glossy, greenish-blue or steel-blue beetle measuring only from 4 to 5 mm. (a little less than one-fifth of an inch) in length; its color varies occasionally to purplish, brownish or greenish. The beetle is shown natural size and enlarged in figure 12. As it is the only small, blue beetle that occurs in injurious numbers upon the grape-vine, it should be a very easy matter for the vineyardist to discover the culprit. The beetles may be found at work on the vines in May and June, and again in July.

While most of the damage is done by the adult insect or beetle,

*Mr. E. A. Schwarz writes us that "The grape-vine *Haltica* of the Pacific slope and Arizona cannot possibly be *Haltica chalybea*, because this species does not occur in the region just mentioned. It is replaced there by *Haltica carinata*."

the leaves of the vine also serve as food for the earlier or grub-stage of the insect. Sometimes considerable damage is done by these grubs or larvæ. It is very important that grape growers should also be able to recognize the grubs, for most of the damage which the insect might do the succeeding season could be averted by killing them. The little dark-brown grubs, shown natural size at work in figure 11, begin to appear on the leaves during the latter part of May and are at work during the most of June in New York. When full grown the grubs measure from 7 to 9 mm. (.275 to .354 inch) in length. They have the six true legs typical of insects, and also one fleshy, yellowish false or pro-leg on the anal segment. They are of a dark yellowish-brown (nearly Ridgeway's raw umber) color, lighter and more yellowish on the venter; the younger grubs are considerably darker in color. The head and thoracic legs are shining black, while the thoracic and anal shields are not quite so densely black in color. The body is marked with regular rows of blackish spots, each bearing a short hair; the size and arrangement of these spots is well shown in figure 13. Fortunately these little brown grubs usually work on the upper side of the leaf so that, although they are only a little more than a quarter of an inch in length, they are easily found by children's sharp eyes.

In the other two stages of its existence—the egg and the pupa—this flea-beetle does no damage. These stages are illustrated and discussed in telling the life-story of the insect.

ITS NAME.

When this flea-beetle was first described nearly a century ago it was given the very apt scientific name of *chalybea;* this word means "steel-blue," the usual color of the beetle. Dr. Harris, in discussing the insect in 1841, popularized this name into "the steel-blue flea-beetle," and also suggested that it might be called "the grape-vine flea-beetle" on account of its habits. Both of these popular names are now in common use, and the former has been shortened by many grape-growers to "the steely-bug" or "steely-beetle." All of these names are very apt and suggestive and we are not sure that the more appropriate one has been chosen for the title of this bulletin.

ITS FOOD-PLANTS.

The natural food-plant of the grape-vine flea-beetle in most parts of the country is doubtless the wild grape, upon which it is often found feeding in both the grub and beetle stages. Other wild plants must serve as natural food for it in some parts of the country; Mr. E. A. Schwarz has found the beetles "abundant on various trees in the semi-tropical hammock of Florida, where the species of *Vitis* do not occur."

Food of the beetles.—The beetles have been found feeding on various plants. In 1856, Dr. Fitch recorded that "a young plum tree in my yard had its leaves nearly all destroyed by this insect, every summer, for many years in succession, and other trees near this were more or less injured;" Britton reports a similar case in Connecticut in 1897. They were reported as feeding on elm by Glover in 1863; in 1888, McMillan stated that in Nebraska the beetles had done much injury to seedling apple, pear, quince and plum trees by eating out the buds, often thus destroying many grafts; in 1892, Schwarz stated that he had found the beetles in great numbers on *Carpinus* (Blue or Water Beech) in Maryland; and they have been found working on the fruit buds of the Dutchess of Oldenburg apple in Minnesota.

Is alder its food-plant?—Most writers in discussing this flea-beetle have quoted the black alder (*Alnus serrulata*) as one of its food-plants. We have traced this statement through the literature to a paper by Dr. Harris published in 1854; in discussing the grape-vine flea-beetle, he states that in a recent excursion to New Hampshire he found large numbers of the beetles and grubs feeding on black alders. However, in Harris' Entomological Correspondence we find practically the same account under the name of *Haltica alni* Harr. MSS.; the dates in the two accounts are the same. Doubtless further study of specimens collected on the alder in 1854 convinced Dr. Harris that they were specifically distinct from the grape-vine flea-beetle, and he gave them the above manuscript name; this insect is now well known as the alder flea-beetle (*Haltica bimarginata* Say). Hence, it is very doubtful if the black alder should be included among the plants upon which the grape-vine flea-beetle, especially the grubs, feed.

Food of the grubs.—While the beetles are quite general feeders, the grubs have been found on but few plants. Most records mention them as feeding only on the leaves of the grape. In

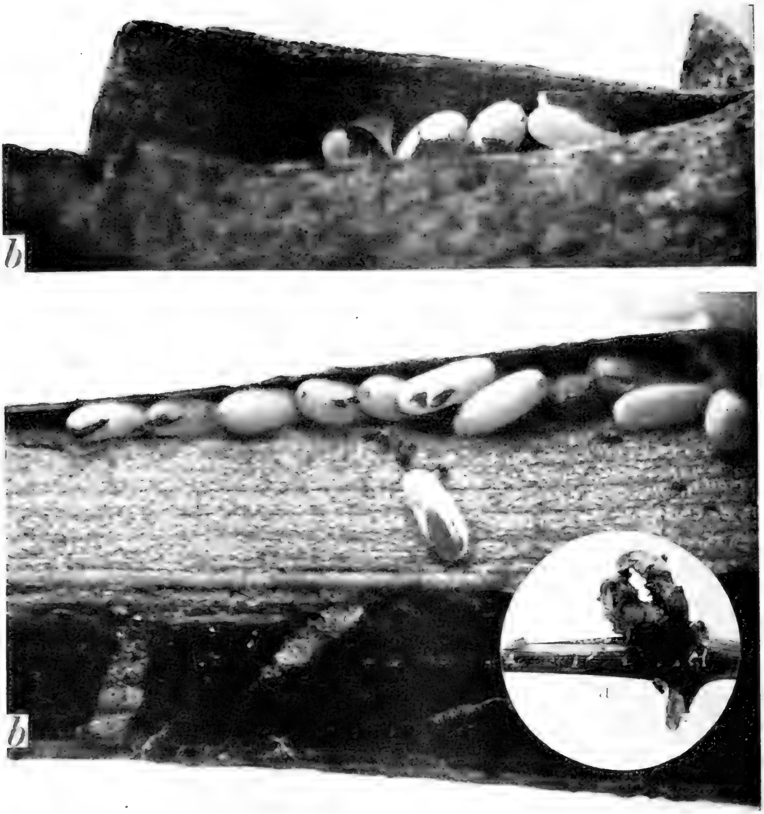
1890, Neal stated that in Florida, "these beetles, both as larvæ and as perfect insects, are injurious, eating the leaves of the plum, grape and peach." In some sections the Virginia Creeper (*Ampelopsis quinquefolia*) seems to be a favorite food-plant for the grubs and beetles. Bethune recently reports that in Canada the insect has been very destructive of late years to the foliage of this vine, the vines were often completely stripped of their leaves before the end of August. Strange to say, a grape-vine against a fence only a few yards from some badly infested creepers was not attacked at all.

Preference for varieties of grapes.—This last fact suggests the question sometimes asked us: Does the flea-beetle attack some varieties of grapes in preference to others? In 1884 one of Mr. Fletcher's correspondents in Canada found that they attacked the Concord grape more than any other. Mr. A. T. Beardslee, Himrod, N. Y., wrote us in June, 1898: "I saw a vineyard of Clinton grapes which was totally devastated by the steely-beetle, while a vineyard of Concords right over the fence remained untouched. The pests commenced eating on the side of the vineyard next to the Concords, and therefore must have passed over the Concords to get at the Clintons. Nothing was left except the hard wood of the vines." Thus the evidence is conflicting and indicates that certain varieties may suffer more in some localities from this flea-beetle than in others, and there is no way of foretelling which variety it may damage the most in any locality.

HOW THE INSECT WORKS, AND ITS DESTRUCTIVE CAPABILITIES.

Fortunately the work of this flea-beetle in a vineyard is easily seen and recognized when one knows what to look for; but, unfortunately it has usually done most of the damage before one suspects that anything is wrong with the vines. Usually it is not until the grape-grower awakens some morning early in the spring to discover that some of his vines have not started into growth as others have. Oftentimes the few vines in some village yard will leaf out all right in the spring, while a neighbor's vines, perhaps only a few rods away, will have the appearance of

16.—*Two grape-vines as they appeared on June 6, 1898, in neighboring village gardens. On vine* (a) *not a bud had escaped the jaws of the "steely-beetle," while vine* (b) *had suffered but little.*

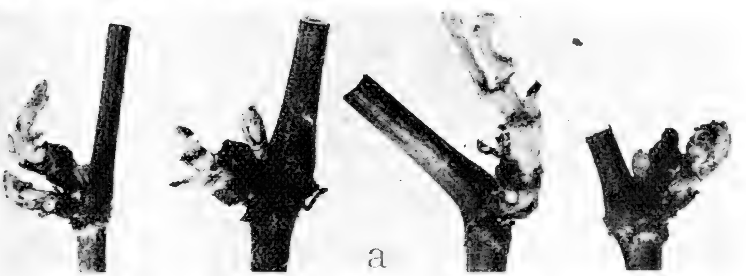


17.—*Eggs of the Grape-vine Flea-beetle ; natural size at* a, *and enlarged at* b, b.

the vine shows at *a* in figure 16. Figure 16 vividly portrays such a case; vines *a* and *b* were in neighbors yards less than five rods apart, and both pictures were taken on the same day, June 6th, 1898.

A careful examination of the buds on vines which thus fail to start normally in the spring will soon show if it is the work of the flea-beetle. Oftentimes many of the buds will be found to have been nearly all eaten up and are dead, like those shown at *b* in figure 15. Many of the buds, not so badly eaten may have just begun a weak, discouraged and deformed growth, like the buds shown at *a* in figure 15. A little further search on the vines at this time will usually reveal the culprit—this steel-blue grape-vine flea-beetle. Often some of the beetles can be caught at their destructive work, perhaps just in the midst of getting their breakfast off one of the buds.

By far the greatest amount of damage done by this grape pest



15.—a, *Grape buds badly damaged by Grape-vine Flee-beetles;* b, *buds killed by the beetles. Natural size.*

is in its attack on the buds in early spring. It has been recorded that vines are often killed to the ground by the attack of the beetles at this time; we have never seen so severe an attack in New York. We have often seen a grape-vine looking almost as bare as *a* in figure 16 in June, recuperate to such an extent that before the summer is over, we would never suspect that it had been injured by this insect, except that such vines lack the element of profit—the fruit.

Thus these flea-beetles, by eating the buds in the spring, attack a very vital part of the vine, so far as the grape-growers pocket-book is concerned. For it is on the season's growth from these buds that all the fruit is borne, and, therefore, every time that the beetle eats a bud, it destroys the crop of fruit which that part of the vine might have produced.

This grape-vine flea-beetle is thus capable of nipping in the bud, the entire crop of fruit, but fortunately it seems to have thus far accumulated in sufficient numbers to do notable injury only over small or isolated areas.

While most of the destruction wrought by this pest is done by the beetle in eating into the buds in the spring, the grubs, or progeny of these beetles, feed upon the leaves later and often do some damage. And again, the beetles which develop in July and August from these grubs, also feed on the grape leaves usually, however, doing no noticeable damage. The work of both the grubs and this later crop of beetles is easily recognized. In figure 19, page 205, is shown a branch on which most of the leaves have been riddled by the grubs; in figure 18 is shown one of the injured leaves natural size. The work of the beetle on the leaves is similar to that of the grubs. This riddling and skeletonizing of the foliage is done by the grubs in June and continued later by the beetles. As many such riddled leaves on the vine presages a destructive crop of the beetles to feed on the buds the next spring, grape-growers finding such leaves should be on the lookout for the pest as soon as growth begins in the spring.

THE STORY OF ITS LIFE.

Appearance and habits in the spring.—The little steel-blue beetles come from their winter quarters in the north in April, or

as soon as the grape buds begin to swell and burst ; sometimes April weather is so cold and unpropitious that the beetles do not appear until in May. They jump or fly to the nearest vine and soon begin to satisfy their appetites sharpened by a long winter's fast. The tender bursting grape bud seems to be the only item on its menu, and it proceeds to gorge itself with bites from the prospective crop of fruit then locked up in the buds. The beetles seem to be the most active during the warmer, sunshiny portions of the day, when they may be seen jumping and flying about the vines. When touched or jarred, they at once drop quickly to the ground where they "play possum" for a short time. Their shining blue color renders it easy to discover and watch them at their destructive work. They begin gnawing an unsightly hole into either the side or top of the bursting bud, and oftentimes boring into the bud so far that they are almost hidden from view. How many grape buds one of the beetles may thus damage, we cannot say ; doubtless several buds are tasted or sampled by each beetle.

It usually takes the beetle a few days to satisfy their vigorous spring appetites, then they begin to turn their attention to the propagation of their kind. Early in May one can often find the beetles in copulation on the vines, often on a bud. Egg laying soon begins.

The egg stage.—Oviposition must have begun with this insect at Ithaca, N. Y., during the first half of May in 1898. How many eggs each female may lay or over how long a period oviposition extends, we have not yet determined. We found the beetles in copulation and freshly laid eggs as late as June 15th, 1898 ; this would indicate that either some of the beetles emerge from hibernation much later than others, or that it takes a female several weeks to lay her stock of eggs.*

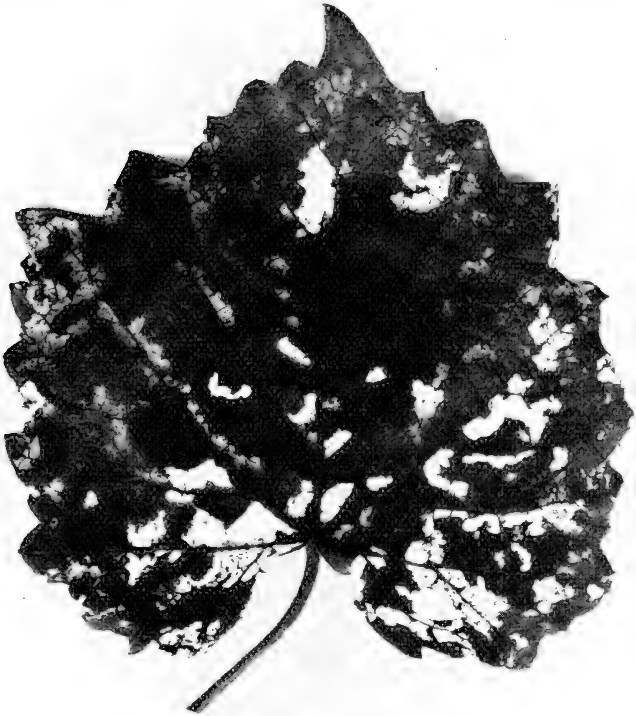
*On July 15th, 1898, Mr. V. H. Lowe, entomologist at the New York State Experiment Station, wrote us that "Yesterday while looking through some vineyards near Bluff Point, N. Y., I found a few eggs on the underside of a leaf. The adult female was there and had evidently just deposited them." We are unable to satisfactorily explain this instance of late oviposition. It may be that this female was so belated in emerging from hibernation as to have not yet finished laying her quota of eggs. The possibility of there being a second brood of the grubs in New York will be discussed later under the heading, the number of broods.

Most writers who mention the eggs, state that they are laid in small clusters on the leaves. Consequently, as soon as we saw the beetles in copulation in May, a careful search was made for eggs on what few leaves had then expanded. We found none, and failed to find any on the leaves in 1898 at Ithaca, N. Y., the few found June 15th, were among the hairs on the stem of a leaf. Our observations indicate that most of the eggs are laid before but few, if any, leaves have expanded. We finally found the eggs in the place shown in figure 17. Most of them were tucked into a crack of the outer bark at the base of the buds, many were scattered in any crevice which afforded room on the base of the bud, and a few were found in the cavity which the beetles had eaten in a bud. These observations agree with those recorded by Perkins in 1878. But Comstock reports in 1880 that "the eggs are laid in irregular clumps of four or five, more or less, both upon the upper and under sides of the leaf. Rarely a few eggs are to be found upon the unopened buds, and the beetles, if caught early in the season and kept in confinement, will oviposit profusely upon any substance whatsoever."

The long, oval shape of the eggs is well shown in figure 17. They are of a darkish straw color (very near Ridgeway's saffron and buff yellow) and average .65 mm. (.03 inch) in length. Their surface presents a dull, roughened appearance, but we were soon surprised to find that this rough exterior layer often cracked open and partially peeled off the egg; this is shown on several of the eggs in figure 17. We found that by a little careful manipulation with a needle, this rough layer could be entirely scraped off from an egg. Whether this layer is a part of the shell of the egg or simply a protective coating secreted over the egg, we did not determine; it was so regular in thickness and presents such a shell like appearance on the outside, that it would seem to be a part of the egg-shell. Its peeling off is a curious phenomenon which we have not before encountered in our study of insects. Beneath this rough coating the egg is smooth and of a shiny, light lemon-yellow color.

How long the egg stage lasts, we did not determine, and the only statement we have found regarding it is by Perkins, who says that "they hatch in about three weeks." Doubtless climatic changes influence the duration of the egg-stage somewhat. At Ithaca, N. Y., the eggs had just begun to hatch on May 27th, 1898; the first leaves had just expanded.

Habits and growth of the grubs.—In Georgia, the young grubs have been found at work as early as March 15th, but in the North, it is usually during the latter part of May that the grubs begin work. The newly hatched grubs are scarcely a sixteenth of an inch long and of a very dark brown color, almost as dark as the blackish spots on the body. We saw some of them get their



18.—*A grape leaf riddled by the grubs of the Grape-vine Flea-Beetle. Natural size.*

first meal on the buds what were struggling to make a little growth with what life was left after being ravaged by the beetles. Usually, however, the little grubs make their way to the young leaves, where they begin to eat little irregular holes through the skin and into the soft inner tissues. Fortunately for the grape-grower, these grubs work almost entirely upon the upper side of

the leaf where they can be easily gotten at with a spray. Several of the grubs usually work on the same leaf, continuing to eat small irregular holes, through or nearly through the leaf until it is pretty well riddled like the one shown in figure 18, when they seek new pastures. Where the grubs are numerous, all of the leaves on a branch may be riddled, as in figure 19, page 205.

As the grubs increase in size they have to shed their skin from time to time, at least two or three times. In shedding their skin or moulting, the old skin splits down the back, about a third of their length, and the grub with its new suit quietly crawls out, leaving its old suit stretched out on the leaf resembling somewhat one of the grubs which might have gotten too warm and had simply unbuttoned its coat down the back a little way to cool off. One of these cast-off suits is shown magnified, at *b* in figure 14.

The grubs continue to feed upon the upper surface of the grape leaves for three or four weeks before they attain their full growth. The full grown grub is represented in figure 13. They are then scarcely a third of an inch long and their general color is considerably lighter than when young, so that the dark markings are more easily distinguished. Owing to their small size, the grubs of this grape pest are not often noticed by the grape-growers; in fact we fear that but few who suffer from this insect are familiar with it in the grub state. However, the work of the grubs is easily seen, and grape-growers should learn to know them, for one of the most effective methods of controlling the insect depends upon this knowledge. In New York the grubs are to be found at work during the first three weeks in June.

The pupa stage.—When the grubs have fed sufficiently they drop from the grape leaves, and after working their way for from one-half an inch to two inches in the ground, they twist and roll themselves about until a small smooth cavity is formed around them. In this cavity they change in a few days to the inert stage in their existence—the pupa. In New York many of the grubs were full grown by June 15th, 1898, and a few days later most of them had left the vines and disappeared in the ground. By June 27th most of them were in the pupa state in their little earthen cells.

One of these pupæ is shown, much enlarged, at *a* in figure 14,

facing page 191. They are of a saffron-yellow color, with reddish-brown eyes. Each segment bears a row of short blackish hairs across the dorsum, and a pair of comparatively large, curved, blackish spurs project caudad from the dorsum of the anal segment.

In our cages in the insectary, the pupal stage of this flea-beetle lasted but little more than a week; for on July 7th, the pupal skin had been cast off and the mature or adult insect—the steel-blue beetles—had begun to emerge from the soil. The indications were that the beetles remained in the earthen cells or pupal homes for a day or so before emerging. They continued to emerge in our cages for a week or more.

Habits of the beetles in the summer.—Fresh grape leaves were placed in our cages where the flea-beetles began to emerge from the ground on July 7th. They at once began feeding upon the leaves, eating small irregular holes, usually from the upper surface, nearly through, often leaving part of the fuzzy, lower skin of the leaf. Leaves upon which they fed looked very much like those eaten by the grubs in June; thus figures 18 and 19 will serve to illustrate both the work of the grubs and of the summer brood of the beetles. The beetles in our cages fed almost continuously for many days; their little string-like pellets of excrement were thickly scattered over their feeding grounds. Some of the beetles thus continued to feed on the fresh grape leaves placed in the cages for nearly two months. The cages were left in a warm greenhouse, and yet many of the beetles ceased feeding and hid themselves in the refuse of dead leaves at the bottom of the cage.

Thus there is no question but what the beetles which emerge in July feed during the rest of the summer, and they evidently thrive upon grape leaves. Comstock records that he had heard reports of considerable damage being done to the grape-vines by the beetles in the summer. But is the grape-vine their favorite food-plant during the summer? During July and August, when the beetles were feeding ravenously on the grape leaves in our cages we made several attempts to find them or evidences of their work in vines which had been quite badly damaged by the beetles on the spring and by the grubs in June. Our efforts were

unsuccessful, yet we feel sure that these vines will be badly damaged by the beetles in the following spring. Our observations would indicate that the summer brood of these beetles must sometimes feed upon several other plants beside the grape. Dr. Fitch records that they fed upon one of his plum trees every summer for many years.

Number of broods each year.—In 1865, Kirkpatrick thought there were several broods of this flea-beetle each year. Most later writers say one brood, while some suspect two broods in the south. There is, as yet, no definite evidence to show that two broods of the beetles and their grubs are produced in a year in any portion of the country, although such a definite statement has crept into one of our best popular books upon injurious insects. As the grubs get to work as early as March in Georgia and Florida, it would seem very probable that another brood of grubs would be developed there before autumn. Bruner has noted but a single brood in Nebraska. In June, 1898, we collected many of the first grubs to be found that had attained nearly their full growth and placed them in cages. The first beetles to develop from these appeared July 7th. We fed the beetles for about two months, and during that time failed to see any in copulation or any indications of egg-laying. They then ceased feeding and prepared for hibernation. This indicates but one brood, normally, in New York.

As recorded on page 195, we found freshly laid eggs on June 15th, 1898, and Mr. Lowe found some as late as July 14th. It is possible this last case means that there may sometimes be a partial second brood of the grubs in New York, but we prefer to believe it a case where the beetle emerged from hibernation much later than usual in the spring, and possibly its egg-laying period was unusually long.

Most writers speak of the beetles which appear in July as the "second brood." There is but one brood of the beetles in a year in northern latitudes at least. It is true, however, that members of two different broods of beetles appear on the vines during the same calendar year. But the beetles which appear and feed on the leaves in July and August are the same ones that one sees eating the buds the next May.

How the insect passes the winter.—In 1859, Dr. Fitch found the beetles torpid in winter beneath loose scales of bark on the vines and under particles of dirt at the base of the vine. This fact, that the insect passes the winter in the beetle state, has been confirmed by all later observers. The beetles hibernate in almost any crevice which will afford them shelter; the rough bark of the supporting posts, under the outer bark at the base of the vines themselves, in the joints of neighboring fences, under sticks, stones, or logs upon the ground, all these are favorite places for their hibernation, One observer (Fisher, 1879) reports that they appear to prefer to hibernate in adjoining grass-grounds or in other substances about, rather than in the vineyard; in vineyards kept clear of all rubbish and other possible hibernating shelter, this is doubtless true. Our breeding experiments detailed above, indicate that the beetles which are developed in July in New York feed during the summer, and finally go into hibernation early in autumn, possibly sometimes as early as the latter part of August. It is these hibernating beetles which emerge from their hiding places in April and May, or earlier in the South, and, with appetites sharpened by their long winter's fast, devour the bursting grape-buds.

ITS NATURAL ENEMIES.

Like most other insect foes of the fruit-grower, this grape-vine flea-beetle has its natural enemies which render more or less aid in reducing its numbers. It is probable that the beetles are sometimes attacked by a fungous disease, for Comstock records receiving specimens from Georgia found under the bark of vines that were fastened to the bark and surrounded by a mass of white fungous spores.* We have not heard of any fungous-killed beetles being found in New York.

In 1889, the late Mr. George C. Snow, Penn Yan, N. Y., detected a nymph of one of the common "stink-bugs" sucking the juices out of the grubs of this flea-beetle. The nymph was

* In the Year Book of the U. S. Dept. of Agriculture for 1895, is figured, page 395, without comment, an instance of the beetle having been killed by a fungus.

sent to Dr. Lintner, who referred it to an expert, Dr. Uhler, by whom it was determined as probably the "stink-bug" known as *Podisus modestus* Dallas. In 1856, Dr. Fitch recorded this bug as puncturing grape leaves; it is more likely, however, that the bug was on the vines for the more useful purpose of sucking the juices from some of the grape-growers insect foes.

On May 30, 1898, we saw one of our most common lady-bird beetles (*Megilla maculata*) eating a young grub of the grape-vine flea-beetle. Thus this pest has its enemies in New York, but, thus far, they have apparently done but little to hold it in check in most localities.

HOW THE INSECT MAY BE CONTROLLED.

This grape-vine flea-beetle is not a difficult insect to combat *when one understands its habits and life-history.* This last clause is italicized because we believe that to a lack of such knowledge is largely due the frequent reports one hears of grape-growers being unable to check the insect in their vineyards. The insect is vulnerable and readily gotten at in two of its stages—as a beetle and as a grub.

Much good can often be accomplished by going through the vineyard, either in the fall, winter, or early spring, and removing and burning all loose bark and splinters from all the vines, and all rubbish from the vicinity of the vines, thus destroying many of the beetles in their hibernating quarters. Comstock records an instance where a Georgia grape-grower reduced the crop of beetles from several bushels to only about a hundred individuals by thus thoroughly going through his vineyard twice in the winter.

Do not allow the beetle to get the start of you in the spring. Be on the lookout for them as soon as the grape buds begin to swell, or during the first warm spell in early spring. Remember that in one day at this time a single beetle is capable of doing more damage than all of its progeny may do during the rest of the season. Your crop of fruit for the season is locked up in those few buds which the pruning-knife leaves on each vine, and it does not take long for the hungry beetles to "nip the crop in the bud." Often grape-growers do not realize that the insect is

present in their vineyards in alarming numbers until most of the damage is done.

There are two methods of combating the beetles in early spring when they emerge from hibernation and attack the bursting buds. They may be collected by hand, or the spraying machine may be brought into use. Both methods are practicable and have proven successful when properly applied.

On a few vines in a village yard or in the farmer's garden, it should be an easy matter to control the pest by examining the vines carefully each morning in May, or oftener if necessary, and crushing in the fingers or otherwise all the beetles to be found. Or the beetles can be readily jarred into a pan of kerosene; this method is often practiced, even in large vineyards. The following modification of this method has been successfully employed: A strip of cotton cloth, 3 by 6 feet, kept open by cross-sticks at the ends, is thoroughly saturated with kerosene and held under the vine, while the supporting-post, or the vine itself, is struck a sharp blow with a club. The beetles readily fall by the jar, and contact with the kerosene sooner or later destroys them. Doubtless it may be found advisable in some cases to use two of these sheets in order that the vine may be more completely surrounded. With this simple apparatus three boys can go over a large vineyard almost as fast as they can walk; and if this be done every day, say for a week, in an infested field, the beetles will be quite thoroughly destroyed. After striking the saturated sheet the beetles show no disposition either to fly or jump. To prevent the possibility of any which might strike the sheet near the edge from crawling off and escaping, simply stitch a rim of cotton batting to the edge of the sheet and saturate it also with kerosene.

A few years ago the beetles destroyed nearly all the buds on some vines near the insectary before we were aware what was the cause of the vines not "starting" in the spring as did others not far away. It was then so late that no attempts were made to check the pest that spring, and other duties prevented our getting in a blow at the grubs, as we might have done, during the summer. But the next spring we were on the watch and as soon as the advance guard of the enemy appeared on the swelling buds

it found that a dose of poison had been included in its first menu. We had thoroughly drenched every bud with a strong Paris green mixture; the buds will stand the poison at the rate of one pound in 50 to 75 gallons of water, providing an equal amount of freshly-slacked lime is also added. Literally paint the buds with this mixture, and renew the application in a few days, or sooner if rains occur. Any of the other similar arsenical mixtures, like London purple, Kedzie's white arsenic mixture, arsenate of lead, or green arsenite will doubtless prove equally as effectual as Paris green. The measure of success of this method will depend entirely on the thoroughness with which it is carried out. We saved the grape buds the season we tried this spray. The method is practicable and our experience demonstrates to us that it can be made a paying success.

It is thus possible and practicable to successfully combat the pest early in the spring before it can do much damage on the buds. It is only necessary to exercise a little watchfulness and be on hand with your kerosene pan or sheet, or your poison spray, the moment the advance guard of the beetles are seen on the buds. Of course, one should always endeavor to check the pest thus early in the season before it ruins the prospective crop of fruit. But oftentimes it happens that the grape-grower awakens to his danger too late; perhaps he did not realize that the pest was in his midst or he may not understand its habits and life-history. Can he do anything that season to prevent a like destruction of his grape buds the next spring? This is the query we are usually called upon to answer whenever our attention is called to this pest.

Yes, grape-growers can strike a very effective blow at the insect later in the season after the beetles which ate the buds in the spring have practically disappeared. First, the grape-grower must learn to recognize the little brown grubs or larvæ of this flea-beetle, so that he may know what he is to fight. Those fruit-growers who understand what they are spraying for get much more satisfactory results than those who spray simply because their neighbors do.

It should be a very easy matter for the grape-grower to make himself familiar with the grubs of this grape-vine flea-beetle

and their work, after reading our discussion of when, where and how they work and how they look. Their work is quite conspicuous (figure 19) and as they usually feed exposed on the upper side of the grape leaves, it is an easy matter to locate them and to hit them on their feeding ground with a spray. Experiments have shown that the grubs readily succumb to a spray of whale-oil soap (1 pound in 6 or 8 gallons of water) or kerosene emulsion; but as these insecticides kill by contact, it is necessary to hit the grubs themselves with the spray. A less expensive and easier method is to spray the infested foliage with Paris green or some other poison, thus poisoning their food. For this purpose the poison need not be used as strong as on the buds to kill the beetles; a pound of Paris green in 150 gallons of water is strong enough to kill the grubs quickly.

19.—*Grape foliage riddled by the grubs of the Grape-vine Flea-beetle; reduced in size.*

We would strongly advise all grape-growers who have this pest to fight to devote considerable of their energy toward killing the little brown grubs of this flea-beetle when they feed on the leaves

in June in New York. Why? Because it is these grubs that develop into the beetles which emerge in July, go into hibernation in the autumn, and come forth in the spring to devour the grape-buds. Thus every one of these grubs that is killed in June means one less beetle to nip your crop of fruit in the bud the following spring. Hence it is exceedingly important to kill every grub possible in June. Fortunately, the grubs are easily accessible and readily succumb to the proper spray. We cannot too strongly emphasize this point that grape-growers should make every effort to kill the grubs of this pest in June. The grubs can be fought much more easily and successfully than the beetle.

Oftentimes it will be found necessary to spray only portions of a few vines to kill most of the grubs. This can be readily done with a knapsack sprayer. We believe that by thus spraying their vines in June our New York grape-growers can reach this pest in its most vulnerable place, and at the same time insure their fruit buds from attack by the beetles in the spring.

In brief then, the grape-vine flea-beetle can be easily controlled by the thorough use of a poison spray on the bursting buds in early spring, or the beetles may then be collected from the buds in pans of kerosene or on sheets soaked in kerosene. Follow up this treatment in the early part of June by spraying the vines with Paris green to kill the grubs then feeding on the upper surface of the leaves; every grub killed then means one less beetle to hibernate and attack the buds the next spring. Be sure and kill the grubs in June.

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Webster. *The Ohio Farmer*, 31st May, p. 437; 7 June, p. 457; 21 June, p. 497. Notes.
Sempers. Inj. Insects, p. 118. Brief compiled account.
Slingerland. *Rural New Yorker*, p. 151. Brief compiled account, with means against; *The Grape Belt*, 15 June. Successful Expts. Paris green.

1895. Webster. *Ohio Farmer*, 19th Dec., p. 493. Notes.
Smith. Economic Entomology, p. 219. Brief account.
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1897. Wickham. Can. Ent., XXIX., 33. Distinctive characters in table.
Panton. Bull. 105, Ont. Agr. Col., p. 11. Brief.
Slingerland. *Rural New Yorker*, p. 420. Brief account, with spraying expts.

1898. Slingerland. *Rural New Yorker*, p. 448. Similar to 1897 account; 11th. Rept. Cornell Expt. Sta., p. XI. Brief note.
Bethune. 28th Rept. Ont. Ent. Soc. (for 1897), p. 33. Brief note on injuries.

1898. Britton. Rept. Conn. Expt. Sta. for 1897, p. 316. Brief note of feeding on plum leaves.

E. T. R. *Rural New Yorker*, July 2, p. 471. Extent of injuries in Central New York and remedial methods used.

SYNONYMS.

Galeruca janthina Le Conte.

1824. Le Conte. Ann. Lyc. Nat. Hist. N. Y., I., 173 Original description.

1853. Melsheimer. Cat. Coleopetra 120. Listed.

1893. Horn. Trans. Am. Ent. Soc. XX., 132. Synonomy.

Chrysomela vitivora Thomas.

1834. Thomas. Silliman's Am. Journ., XXVI., 113. Original description.

1835. Herrick. Silliman's Am. Journ. XXVII., 420. Gives letter from Harris making it a synonym.

1889. Horn. Trans. Am. Ent. Soc., XVI., 220. Synonomy.

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156. Third Report on Potato Culture.
157. The Grape-vine Flea-beetle.

Bulletin 158. **January, 1899.**

Cornell University Agricultural Experiment Station.

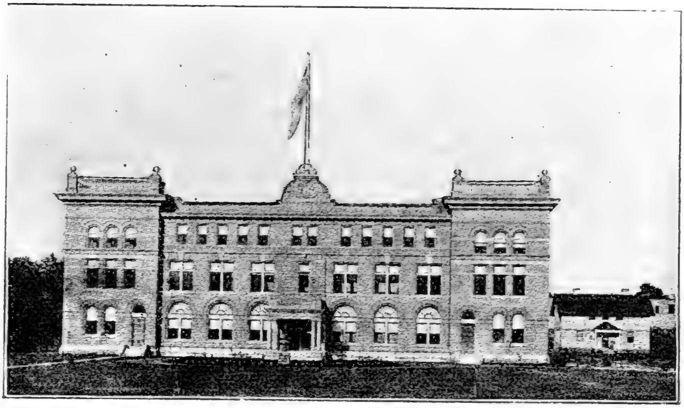
ITHACA, N. Y.

VETERINARY DIVISION.

AN INQUIRY CONCERNING THE

Source of Gas and Taint

PRODUCING BACTERIA IN CHEESE CURD.



NEW YORK STATE VETERINARY COLLEGE.

By V. A. MOORE and A. R. WARD.

PUBLISHED BY THE UNIVERSITY,
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1899.

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CORNELL UNIVERSITY, ITHACA, N. Y., Dec. 7, 1898.

THE HONORABLE COMMISSIONER OF AGRICULTURE,

ALBANY, N. Y.

Sir: This bulletin is submitted for publication under Chapter 67 of the Laws of 1898.

The presence of gas, accompanied by undesirable taints in cheese curd, has long been known to be a potent factor in lessening the market value of cheese.

A few bacteriologists have found that the cause of the gas and taints is a gaseous fermentation due to the presence of certain bacteria. The particular species of bacteria which produce this fermentation have not heretofore been clearly defined; their source or the channel through which they get into the milk has not been definitely pointed out. While, therefore, this trouble has been attributed with reason to bacteria, the definite knowledge of species and of means for carrying out intelligently preventive measures was wanting.

The purpose of this bulletin is to point out one of the species of bacteria which causes this trouble; the channel through which it gets into the milk; and the precautions necessary to be taken in order to prevent its appearance.

It has been necessary to restrict the inquiry to the conditions arising in a single factory and in a single dairy. It cannot be assumed, therefore, that the result obtained can without further investigation be used to explain the cause of this trouble in all factories.

The investigation has brought out in a most conspicuous manner the necessity for a large amount of bacteriologic investigation in determining the effects upon milk, butter and cheese of a large number of bacteria commonly present in the excreta of cattle.

This inquiry has brought out several facts, heretofore generally denied, concerning the source of bacteria in fresh milk. The research demonstrates that bacteria do exist sometimes in the milk ducts of the udder itself as well as in the teats. It is also shown that the same species of bacteria will persist in the udder for a considerable time if once introduced. This is highly important in showing the necessity for cleanliness in cow stables.

The investigation, as a whole, has opened a new field and will without doubt lead, in time, to extremely valuable results. The only regret is that time and opportunity have not enabled the Station to make as extended researches as is desirable. Suffice it to say, the investigation will be continued another year.

I. P. ROBERTS.

DESCRIPTION OF PLATE.

A photograph of a section through the teat and one quarter of the udder of a cow. The parts represented by the letters A. B. C., indicate the three arbitrary divisions into which the gland was divided for purposes of examination.

We are indebted to Dr. G. S. Hopkins for the loan of the excellent museum specimen from which the photograph was taken.

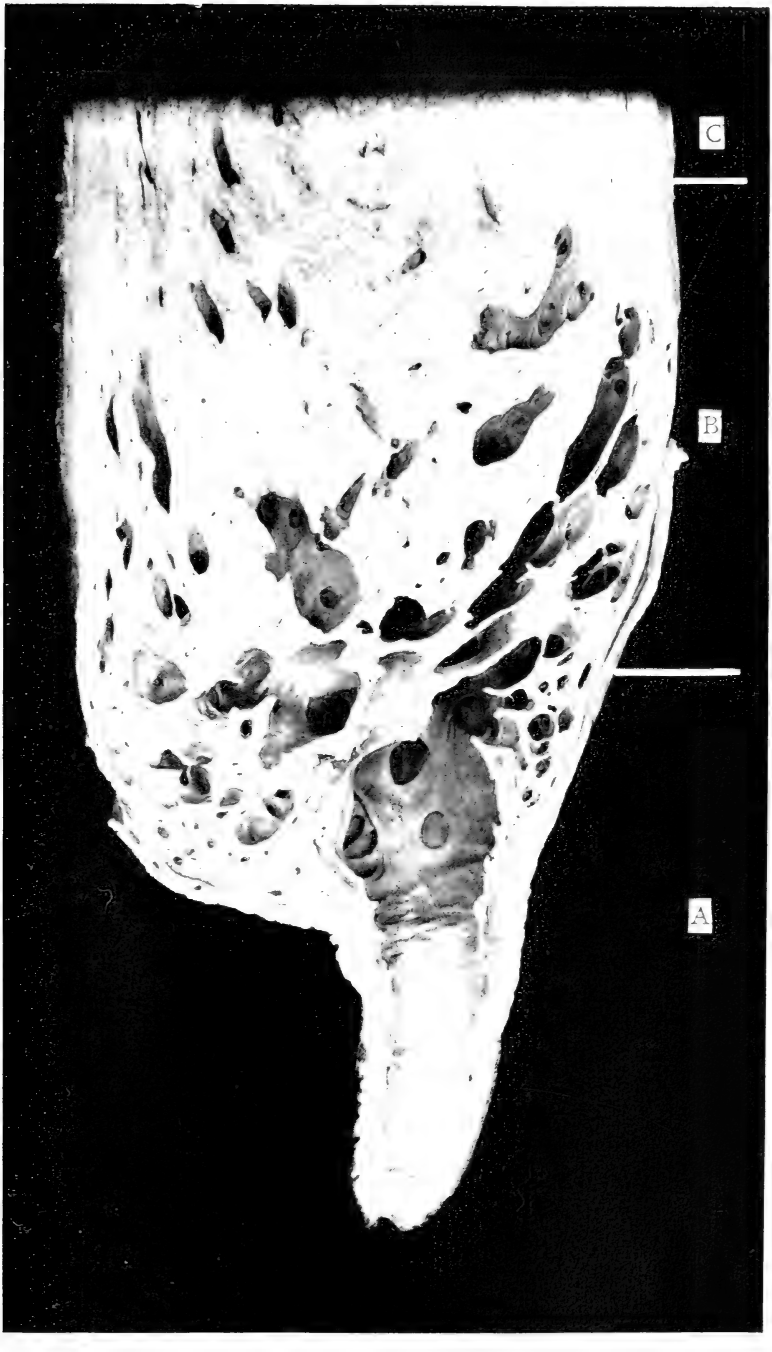

PLATE III.

AN INQUIRY CONCERNING THE SOURCE OF GAS AND TAINT PRODUCING BACTERIA IN CHEESE CURD.

BY VERANUS A. MOORE AND ARCHIBALD R. WARD.

A common trouble encountered by cheesemakers is the presence of disagreeable taints which develop in the milk and curd during the cheesemaking process. Although certain taints, hereafter mentioned, may appear in the milk and curd unaccompanied by the formation of gas, the more common and troublesome ones are constantly associated with, and appear to be dependent upon, a gaseous fermentation. Inquiry has shown that the change in the flavor of the ripened cheese which follows the presence of these bad odors in the milk and in the curd when it is put to press diminishes very materially the market value of the product. Notwithstanding that much of the skill of the cheesemaker consists in his ability to recognize tainted milk when it comes under his control, and to apply measures to prevent the formation of gas, and check or prevent altogether the taints which subsequently arise and give the undesirable flavors, it frequently happens that he is unable to do so. In such cases, the questions which naturally arise, are: What is the cause and who is responsible, the patron or the cheesemaker? The reason for this two-sided question seems to rest in an uncertainty concerning the specific cause. The patrons find it easy to blame the cheesemaker, and he in turn attributes the cause to agencies outside his factory.

Several explanations have been offered for the occurrence of "gassy" or pin hole curd and accompanying taints. Russell and others have demonstrated experimentally the cause to be the fermentation produced by certain bacteria which get into the milk. Lloyd* has shown that among other things, "a diarrhoea which tends to increase the introduction of fecal matter into milk,

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*Journal of the Bath and West and Southern Counties Society, England, Vol. IV, 1894.

is a direct cause." Thus he has pointed out that "certain tracts of the country are not suited to the manufacture of cheese as the excess of certain salts in the soil which are taken up in unusually large quantities by the forage plants, tend to produce a continuous looseness of the bowels." It is well known to American cheese buyers that the most desirable flavors are not found in cheese made from the milk of cattle pastured on certain swampy or new lands. The cause here, is due to the tainting of the milk through the physiologic effect of certain of the plants eaten by the cattle. A familiar analogous illustration is found in the well known flavors imparted to the milk and butter when cattle are fed upon turnips or grazed in a pasture where wild onions are abundant.

Some dairymen in this country believe that the trouble is attributable to certain abnormal conditions attending parturition. This is based on the observation that frequently, if not always, a few cows in one or more of the dairies furnishing milk to the troubled factory retain the placenta or afterbirth at the time of parturition, and that the conditions thus brought about, cause the subsequent odors in the curd made from the milk.

The painstaking investigations of Russell indicate that the cause of the particular odors and flavors in question are of bacterial origin, and that they have nothing in common with those due to volatile or other substances in the food. Guillebeau has found a close relation existing between the bacteria that are able to produce an infectious mammitis and some forms capable of gas evolution. Several times "gassy" milk has been traced directly to animals suffering from an acute inflammation of the udder in which it has been affirmed that the organisms producing the disease were a direct cause of the gas production in the milk. Guillebeau* found three bacilli which he believed to be the cause of inflammation of the udder, and which possessed the power of causing a well marked cavernous structure in the cheese.

In the summer of 1897, an opportunity arose to inquire into the cause of "gassy" curds and taints in a factory receiving milk from a dairy in which there had been considerable trouble

*Quoted by von Freudenreich. Dairy Bacteriology, page 57, English translation by Davis.

from retained placenta. This investigation promised to throw some light upon the relationship of the alleged cause to the trouble. The outcome is not altogether conclusive concerning the possible initiative significance of the retained placentas, but as it offers many suggestions relating to the actual source of the special taints in question, a report of progress seems desirable. This is made the more urgent from the fact that the taints in the milk from this particular factory were pronounced by Instructor Hall, and by others, to be the same as those which are causing the greatest amount of trouble in the factories throughout the State.

In the case in question, the factory was furnished with the milk from two dairies; one of these belonged to the owner of the factory and farm on which it stood, and the other to a neighbor. The dairy on the farm and in which the parturition trouble occurred, consisted of twenty-five cows. During the winter of '96–'97 the cows had been given a heavy grain diet. The animals were housed in a comfortable stable which was kept clean from the standpoint of the present popular ideas of stable cleanliness. They were all in good condition. The factory opened late in March, as early as there was sufficient milk, and the curd was of the finest quality. It so happened a little later, that at the time of parturition, the placenta or afterbirth, was retained by eleven of the cows. As these were not properly attended by a veterinarian, the retained membranes were not removed but allowed to decompose *in utero* and to be discharged. This gave rise to an intensely disagreeable (putrid) odor about the stable. Soon after this happened, the peculiar taints in the milk with "gassy" curd began to appear.

The cause of the trouble was at once attributed to the cows which discharged the retained and decomposing placentas. It was to ascertain, if possible, whether or not this was the cause, that the present investigation was undertaken. Unfortunately, the trouble had been going for several weeks before it came to our notice and, meantime, the affected cows had recovered, but the tainted and "gassy" curds continued to appear and to cause a serious depreciation in the value of the cheese.

In the investigation, it seemed best to begin with the "gassy" and tainted curd to find if possible the specific cause, and then to look for its source. Without entering into the technicalities of the methods followed, the results of a careful bacteriologic examination of the curd showed that both the taint and the gas were caused by the same species of gas producing bacteria, a microörganism resembling very closely, if not identical with, *Bacillus coli communis*. The evidence of the correctness of this assertion is based entirely on the fact that when cheese was made with milk which had been sterilized and then inoculated with this bacillus, that the "gassy" curd and the taint in question would develop.

The factory itself was kept scrupulously clean and the only possible source for the organism there seemed to be in the rennet or in the water used in cleaning the vats. These were both subjected to a thorough bacteriologic test for gas producing bacteria with negative results. This outcome practically eliminated, as was expected, all suspicion that the organism came from the factory. It was then determined by making the milk up separately from the two dairies that the bacillus which was causing the trouble came to the factory in the milk from the dairy on the farm. It remained to be found whether its presence in the mixed milk was due to the dust and filth which invariably fall into the pail from the flanks and udder of the cows at each milking, or, whether it was in the milk ducts themselves, and if so to determine which cows were thus infected.

Cheese was made at our suggestion leaving out the milk of the cows which were reported to have suffered from the retained placenta without, however, any improvement in the condition of the curd. This necessitated a careful examination of the milk from each cow in the dairy. This was made from a series of samples taken daily for a period of two weeks.

The bacteriologic examination consisted in testing for gas producing bacteria, using the fermentation tubes and also the curd test recommended by Russell of the Wisconsin Agricultural

Experiment Station.* Before collecting the samples of milk the cows' flanks, udders, teats, and the hands of the milker were washed with a 1 to 1000 solution of corrosive sublimate. The jars in which the milk was to be collected were sterilized by boiling. The outcome of this series of observations showed the gas and taint producing bacteria to be present more or less constantly in the milk of each animal. In addition to the gas, the curd tests emitted the disagreeable odor. These were invariably present in the test curds made from the milk of certain of the animals while those made from the milk from the other cows were not constantly bad, there being occasionally days in which the taints were less marked or absent altogether.

In the above tests the fore milk was used. The examination was repeated, however, with the milk from several of the cows in which that taken from the middle or latter half of the milking was used. Similar positive results were obtained showing that the rejection of the fore milk from all of the cows would be of little or no use in checking the trouble.

A study of the results obtained from the daily examinations of the milk from the different animals, gave no assurance that the trouble wonld be eliminated by keeping out the milk from any particular cows. The interesting fact was brought out that the test curds made from the milk of the cows which had suffered from retained placenta were, as a rule, no worse than those made from the cows which had not been so affected. The cows from which the constantly bad curds were obtained were among those which had had a normal delivery.

The positive results obtained in the test with the fore milk, naturally led to an examination of the dust and filth from the floor of the stable. As in the other examinations this consisted simply of a search for gas producing bacteria. Several varieties or species were isolated and studied, but none of them resembled

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*Samples of milk placed in sterile vessels are allowed to stand in a moderately warm place for several hours after which rennet is added. Gas producing bacteria will, if present, cause the formation of gas bubbles in the curd, similar to those encountered in the cheese vat. The test is fully described in the Twelfth Annual Report of the Agricultural Experiment Station of the University of Wisconsin, page 148 and in Bulletin No. 67 of the same station.

very closely the one isolated from the "gassy" curd although they approached it in some one or more of their properties. After a careful but fruitless search in these substances for this organism the conclusion seemed to be supported that this bacillus was not widely disseminated at that time in the stable. This suggested that the obnoxious organism got into the milk through the teat infection rather than on the particles of dust which fall into the milking utensils. A further argument for the teat infection rests in the fact that after the stable was thoroughly cleaned and disinfected, the trouble continued without immediate abatement. Gradually, however, it began to disappear, and late in the fall it had practically ceased. The constant cleansing prevented reinfection so that when the teats happened to be cleared of this organism they were not again infected with it.

It has long been known that the fore milk when drawn under aseptic precautions contains bacteria. Their presence is generally supposed to be due to the infection with the bacteria which chance to get upon the end of the teat, multiply there in the remaining drop of milk and gradually grow up on the mucous membrane of the milk duct from which they are washed out during the subsequent milking. The examinations made in the present investigation suggested that the gas and taint producing bacteria had, in addition to this temporary invasion, become colonized in the udders of certain of the cows. This, however, could not be positively determined.

Although the present knowledge of the extent of the bacterial invasion of the udder presumes that it is not extensive and under normal conditions probably does not reach beyond the teats, it seems difficult to explain the results obtained without presuming, as did Gernhardt, that sometimes the bacteria grow up through the teat and cistern into the ducts of the glandular tissue. A few months after this investigation, we had the privilege of examining bacteriologically the udders from several freshly slaughtered milch cows and found that the mammary gland is, sometimes at least under presumably normal conditions, invaded with bacteria. This fact strengthens our belief that in the case of the gas producing bacteria, they had invaded the udder itself and become colonized there. As the results of the bacteriologic

examinations of the udders are of special significance in reference to the source of the bacterial infection of milk, a brief statement concerning them seems desirable.

In January, 1898, Dr. Cooper Curtice, inspector for the State Board of Health, invited us to be present at the killing of a herd of cattle which had responded to the tuberculin test. The udders of six cows, all of which were in good condition were carefully examined. The post-mortem examination showed the tubercular lesions to be restricted to a few small nodules in the bronchial and pharyngeal glands. The cows were milked just prior to being killed. Specimens of the fore milk were taken. Each quarter of the six udders together with the milk specimens from each were examined bacteriologically.* The possible criticism that these animals were tuberculous does not seem to detract from the results as the cows were in good condition and the obvious lesions were, as already stated, restricted to a few tubercular foci. After making the cultures the udders were very carefully examined for tubercular or other lesions, but they could not be found. For convenience in noting results the gland was divided arbitrarily into three parts as follows: (A) The lower third including the teat and cistern; (B) The middle third which included the lower half of the gland proper, and (C) the upper third, which included the remaining portion of the gland. (See plate.)

The same species of bacteria† were found in the fore milk, cistern and middle and upper thirds of the udder from each animal. It should be remembered that the examinations were made almost immediately after the cows had been milked dry. In some instances the same organism was found in each part (A. B. C.) of a quarter of a gland, while in others, the bacteria were more irregularly distributed. The cultures made from the tissues from the middle and upper thirds of a few quar-

*The methods employed were those ordinarily used in milk analysis. The description of the details and an account of the results of the examination from each individual quarter of the glands are held for a future publication on the bacterial invasion of the normal udder.

† The predominating form was a micrococcus which grew in a yellow or buff colored colony.

ters remained clear. In making these cultures pieces of the glandular tissue as large as an average sized bean were used. The number of colonies was small in all cases. However, the essential fact is that bacteria were there and remained there after milking, ready to infect the milk of the next succeeding milking.

During the summer of 1898, a second opportunity for examining two udders under like circumstances was availed of. In these cases the same organism, a micrococcus was found in cultures from the milk and from different parts of the mammary gland. Gas-producing bacteria were not found in any of the udders examined.

The investigations heretofore reported, have not shown, as a rule, the presence of gas-producing bacteria in the fore milk. It is only occasionally that we find in the records of these investigations a statement of the presence of gas-producing organisms. Bolley and Hall* examined the milk of ten cows for a period of three months without encountering gas-producing bacteria. Others have recorded practically the same results. This is significant in suggesting that the normal intestinal bacteria, especially *Bacillus coli communis*, does not under ordinary conditions invade the milk ducts. Likewise, a vigorous gas-producer, *Bacillus cloacæ* which is found in the soil does not seem to become localized in the udder.

It will be seen from the description (p. 234) that the bacillus isolated from the tainted curd is closely related to, if it does not belong in the colon group of bacteria.† The evidence collected supports the hypothesis that the milk ducts were in this case invaded with this organism about the time that certain of the cows were discharging the decomposed placental membranes. As the stable was not disinfected or kept as clean as it might have been, it is presumable that the bacteria which became concentrated in large numbers in these membranes were disseminated

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*Centralblatt für Bakteriologie u. Parasitenkunde, Vol. II. Abstract in Experiment Station Record, U. S. Dept. of Agric., Vol. VII., p. 99.

†In the intestines of healthy animals, there is constantly present an organism known as *Bacillus coli communis*. There are many varieties of this species and for convenience all of these varieties are classed together under the general term of the colon group.

throughout the stable, and, coming in contact with the end of the teats, this particular species found a suitable place for multiplying and from there grew up into the udder. The examination of the milk from several animals in different dairies fails to show a common invasion with this or similar organisms. A careful comparison of the bacillus obtained with different cultures of *Bacillus coli communis*, isolated from the intestines of cattle, shows that there is an appreciable difference between the two although not enough to place them in separate species. The facts warrant us in supposing that this particular organism possessed, to an unusual degree, power to invade the milk ducts just as certain cultures of a species of pathogenic bacteria possess more virulence than other cultures of the same species.

It is unfortunate that an examination of the milk of each cow was not made early in the course of the trouble. While it is not demonstrated that this organism was present in the decomposing uterine membranes, it has been shown that bacteria of this group often get into the uterinecavity in cases of parturient difficulties. It has also been pointed out that the colon bacteria, like certain other organisms, may have their properties modified when they are grown under different conditions or environment. It would probably have been possible, had the examinations been made at the proper time, to have determined whether the organism in question made its appearance simultaneously with the discharge of the putrid placenta, and whether or not the cows thus affected were the first to have had their milk contaminated with this species.

It has long been recognized that the species of bacteria in the fore milk are modified largely by the conditions under which the cattle are kept. When on green pasture with little or no opportunity to get into mud or filth, the number and species of bacteria in the milk are much smaller and different than they are when the cows lie in filthy yards or stables.

It is important to bear in mind that when certain bacteria get into the milk ducts of the teat, or possibly in those of the udder itself, there is a tendency to become localized and to remain there for a considerable time, while other species do not take readily to this environment. In the examination of the fore milk from

one of the cows of the University dairy, two species of micrococci and one of a streptococcus were found to persist for several months. The examinations made at different times showed first one and then the other species to predominate in numbers. After about eight months, however, the micrococcus disappeared from one quarter, leaving the streptococcus only, but the micrococcus remained in the other quarters. In another animal a staphylococcus has persisted in the fore milk for over eight months. The fact to be emphasized is that certain species of bacteria sometimes do persist in the milk ducts.

The question has often been asked if the bacteria which cause the taint in the milk do not pass through the tissues of the animal from the intestinal tract to the udder. This question has doubtless been suggested by the fact that frequently after the cows begin to drink from stagnant pools, the taints and "gassy" curds begin to appear. The frequent detection in the milk of flavors and odors characteristic of vegetables which the cows have eaten, such as garlic or turnip, may have suggested that bacteria could in like manner pass into the milk. The belief centered in the affirmative answer to this question is so strongly entertained by some dairymen that a word of explanation seems necessary.

Some of the early hypotheses regarding bacteria in the animal body might be construed to mean that such a procedure was possible, but the fact is now well established, supported by the results of many investigations, that bacteria do not pass from the digestive tract to the various glands of the body so long as the animal is in a perfectly healthy condition. This does not imply that such a passage does not under certain abnormal conditions take place, but that it is a common or even a rare normal occurrence, must in the light of our present knowledge, be unhesitatingly denied. The occurrence of tubercle or anthrax bacilli in the milk is not an analogous case, for in these diseases, the bacteria are already within the animal body where they can be carried to various parts by the blood and lymph in their respective vessels.

In order to bring positive evidence to support this reply, two experiments were made to test the power of bacteria to pass from the intestine to the udder. The fore milk of two cows was carefully examined and the normal bacterial content determined.

The cows were then given daily in their drinking water from one to two quarts of a bouillon culture of a *Bacillus prodigiosus*,* and the milk carefully examined but this organism did not appear in the milk although the feeding and examinations were continued daily for nearly two weeks. The experiment was repeated with cultures of the gas-producing bacillus with similar negative results.

From the known facts it is highly probable that the cause of the "gassy" curd made from the milk of cows allowed to drink from stagnant pools is not that any bacteria in such water pass through the animal tissues into the udder, but that the cows wallowing in this water or other unwholesome places, smear the teats and udder with the dirt and filth containing the obnoxious organisms. These bacteria are then either carried directly into the milk on the dried particles which drop into the pail at the time of milking, or else they infect the milk ducts and udder as in the case herein described. There is always left on the end of the teat a small drop of milk in which the bacteria can multiply, and from which they can gradually grow up into the milk passages. In such an infection we have a condition quite similar to the one under consideration.

In the case where the "gassy" curd follows the drinking of stagnant water, it is presumable that a different species of bacteria is the cause. There are a number of bacteria which produce gas and which are found to be widely distributed in nature. How many of these are capable of producing the taint in question is not known, but it is highly probable that several of them could do so. We do not presume the organism we have isolated and studied is the only one to be feared or guarded against. The facts elicited suggest that all bacteria capable of producing a gaseous fermentation in milk, might, if the fermentation process was continued for a sufficient length of time, give rise to objectionable taints and flavors. In our experimental work with the bacillus in question, a considerable variety of taints were detected in the milk and curds. The difference in them depended for their cause upon the length of time the fermentation had been going on. It is not unlikely that this explains in part

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*This organism was chosen as it is easily detected, if present, by the deep red color of its growth on culture media.

the cause for the variety of unpleasant taints and flavors detected by cheesemakers and buyers. The cause for the considerable number of taints however, needs further elucidation, but the experience with this particular species of bacteria indicates that our explanation may be found to be correct. Certainly, the economic importance of these disagreeable taints and flavors render a more thorough and general investigation into the causes and means of prevention much to be desired.

SUMMARY.

The results obtained in the investigation herein reported may be summarized in the following statements:

1. The "gassy" and tainted curds were caused by the action of a certain species of bacteria which was present in the milk.

2. This organism was introduced into the milk at the time of milking. It came from the milk ducts of the teat or, perhaps, from those of the udder. There seems to be no evidence that it was carried into the milk with the particles of dust or bits of dirt which invariably fall into the pail unless special precautions are taken to prevent their entrance.

3. The organism is closely related to *Bacillus coli communis*, a species of bacteria commonly found in the intestinal tract.

4. Positive evidence was not obtained to show that the retained placentas, with their subsequent decomposition and discharge, were the cause of the milk duct infection with the microorganism which produced the gas and taints in the curds.

5. The wide distribution of this organism in the milk ducts of the cattle, and its apparent absence or at least infrequency in the dirt of the stable, indicates that the cattle had been exposed in some way to this organism. It is very likely that the decomposing membranes might have been the channel through which the infection took place.

6. The milk duct infection of all of the cattle in the dairy with this organism was made possible by the fact that the stable was not thoroughly cleaned and disinfected as soon as the trouble with the "gassy" curds and taints began.

7. Certain species of bacteria when once introduced into the udder are able to remain there for a considerable length of time,

thus becoming a constant source of contamination. When this takes place, immediate relief does not follow the cleansing of the stable, but such treatment if continued will probably be efficient.

8. After thoroughly disinfecting the stable and putting it in a clean condition, the milk of each cow should be tested, and the milk of those animals found to be infected should be kept out of the vat until the normal condition is restored.

Prevention.—In the light of the present knowledge of the infection of milk with gas producing bacteria, the best preventive measure seems to be cleanliness, keeping the cows themselves and the stable clean. It is highly important not to have in the stable or about the yard any decomposing animal matter. If there is trouble with retained placentas at the time of parturition, the cows should be properly attended, the membranes removed and disinfectants applied. If these precautions are taken and the same care exercised in cleansing the milk utensils, it is highly probable that a general infection would not take place. Although the method has been reported by a German experimenter, the disinfecting of the milk ducts by washing them out with a suitable germicide through the aid of the milking tube has not been successful in our hands.

The proper care of the animals, the keeping of the stable in a clean, wholesome condition and the occasional use of disinfectants* cannot be too urgently recommended as prophylactic measures.

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* Of the cheap disinfectants the following is very efficient. It is quite corrosive, and care should be taken to protect the eyes and the hands from accidental splashing :

Crude carbolic acid.................................... ½ gallon.
Crude sulphuric acid .... ½ gallon.

"These two substances should be mixed in tubs or glass vessels. The sulphuric acid is very slowly added to the carbolic acid. During the mixing a large amount of heat is developed. The disinfecting power is heightened if the amount of heat is kept down by placing the tub or demijohn containing the carbolic acid in cold water, while the sulphuric acid is being added. The resulting mixture is added to water in the ratio of 1 to 20. One gallon of mixed acid will thus furnish 20 gallons of a strong disinfecting solution, having a slightly milky appearance. The mixture should be applied to the walls and floors of the stable, saturating them with it."

A 5 per cent solution of commercial sulphuric acid can be used. This is desirable as it is free from the objectionable odor of the crude carbolic acid.

A Brief Description of the Gas-Producing Bacillus.

Source.—Tainted "gassy" cheese curd taken from the vat and from samples of test curds made from the milk of individual cows in the dairy furnishing the milk.

Morphology.—An actively motile bacillus. In twenty-four hour bouillon cultures the individual organisms are found to vary in length from 2 to 4μ. They have a uniform breadth of 1.2μ. They are single with rounded ends. When stained with carbol-fuchsin or with carbol-methylene-blue they exhibit a marked polar arrangement of the cellular protoplasm. They stain feebly but uniformly with alkaline methylene-blue. Crystal violet stains the whole of the organism uniformly and deeply. It does not retain the stain when treated by the gram method. Flagella are readily demonstrated by Loeffler's method. Spore formation has not been observed. It does not appear to have a capsule.

Biologic Characters.—This bacillus grows readily on all of the ordinary culture media. Its temperature limitations are from 8° to 40° C. It grows best between 35° and 38° C., and at a low temperature its development is exceedingly slow and feeble. It is aërobic and facultative anaërobic.

Agar.—Surface colonies on agar plate cultures grown at 37.5° C. are circular, flat, with regular, sharply defined borders. They vary according to the number present, from 2 to 4 mm. in diameter. They are not viscid, neutral gray in color, with moist glistening surfaces. By transmitted light the color appears to be darker. The plate cultures emit a penetrating odor resembling slightly that coming from cultures of swine-plague bacteria. The deep colonies are grayish, lenticular shaped masses 0.5 to 1 mm. in length. In slant cultures the growth is of a neutral gray color usually spreading over the entire surface of the medium. The condensation water is clouded with an accumulating grayish sediment.

Gelatin.—Colonies on the surface of gelatin plates are thin, spreading, 3 to 7 mm. in diameter, wrinkled, with irregular but sharply defined borders. With transmitted light the centers have an opalescent appearance, these are surrounded with a

thinner translucent zone extending to the edge. In gelatin stab cultures, the growth along the needle track consists of a series of isolated or confluent grayish colonies which are more numerous near the surface. The surface growth is spreading.

Potato.—A thin brownish yellow growth first appears. After several days in the incubator it becomes thickened and of a brownish color. It is not viscid.

Alkaline Bouillon.—At 37.5° C. the liquid becomes uniformly densely clouded with the accumulation of a grayish friable sediment which is easily disseminated upon agitation. The reaction is acid during the period of most active growth, but it becomes alkaline in about five days. At this time the sediment has a floculent or fluffy appearance extending up into the liquid for several millimeters. In old (3 to 6 weeks) cultures a thin, grayish pellicle forms over the surface.

Acid Bouillon.—The growth is similar but less vigorous in acid than in alkaline bouillon. The sediment is somewhat lumpy or aggregated into dense masses. If undisturbed, a thin pellicle may form on the surface. The reaction finally becomes alkaline.

Milk.—This organism coagulates milk in about three days, when grown at a temperature of about 37° C. The coagulum contracts and becomes covered with a clear serum. The casein is not digested. It is strongly acid in reaction and gives off a sour odor. Occasionally the taint similar to that in the curds can be detected in 24 hour cultures. It is, however, more noticeable in larger quantities of milk.

Gas production as determined in the fermentation tubes with bouillon containing sugars. (1) *One per cent glucose bouillon* —On the day following the inoculation, the liquid in the open bulb is heavily clouded and acid in reaction. In the closed arm, the liquid is less heavily clouded. In the bottom of the tube there is a considerable quantity of a grayish, friable sediment. Gas is present. The maximum amount of gas is produced by the second day. It occupies $\frac{9}{16}$ of the capacity of the closed arm of the tube.

(2) *One per cent lactose bouillon.*—The liquid in the open arm becomes clouded and acid in reaction in 24 hours. The liquid in the closed arm is more faintly clouded. Gas is present. The

maximum amount of gas produced is $3/8$ of the capacity of the closed arm.

(3) *One per cent saccharose bouillon.*—The liquid in the open arm of the fermentation tube becomes decidedly clouded but remains alkaline in reaction. In the closed arm the liquid in the upper part remains clear and that in the lower third becomes very feebly clouded. Gas is not produced.

The analysis of the gas gives the ratio of the gas absorbed (CO_2) by sodium hydroxid to the explosive residue (H) as 1 : 2. This ratio holds true for the gas produced in both the glucose and lactose bouillons.

During the eighteen months that this organism has been under artificial cultivation, there has taken place a diminution in the amount of gas evolved in the fermentation tubes containing the sugar solutions. At present, only about one-fourth of the quantity of gas originally produced is formed.

Thermal Death Point.—This organism is destroyed in freshly inoculated small tubes of bouillon when exposed to a temperature of 60° C. for ten minutes in a closed water bath.

Resistance to drying.—Drops of a bouillon culture placed on sterile cover-glasses under a bell jar, retained their vitality tor sixty days.

Indol reaction.—A strong indol reaction was obtained in 48-hour cultures in Dunham's peptone solution.

Production of the taint.—A quantity of market milk was divided into two equal parts which were placed in the two divisions of a double cheese vat so that each might be made into cheese under identical temperature conditions. To one of these quantities of milk, about 100 lbs., was added two quarts of a 24-hour milk culture of the bacillus. Shortly after adding the culture, a "tainted" odor was observed in the milk of the one vat only. During the process of cheese making the odor in the inoculated vat was observed to become progressively more intense. The curd in this vat became distended with gas to such an extent that it floated upon the whey.

Identical results were obtained during the 1898 session of the Dairy School. The milk used in this experiment was taken from the mixed milk with which the other vats were supplied.

"Gassy" curds or taints did not develop in any of the vats other than the one inoculated. The odor which developed in this vat was identical with that recognized in the vat from which the original culture had been obtained. Mr. W. W. Hall, instructor in cheesemaking, employed by the State Department of Agriculture, identified the taint as the one commonly found in curds where bad flavors subsequently appear in the cheese.

NOTE.—After this bulletin had gone to press we received a copy of Bulletin No. 62, of the Agricultural Experiment Station of the University of Wisconsin, entitled "Tainted or Defective Milks: Their Causes and Methods of Prevention," by Prof. H. L. Russell. The reader is referred to that publication for a more general consideration of the causes of defective milk.

From the Laboratory of Comparative Pathology, and Bacteriology New York State Veterinary College, Cornell University, Ithaca, N. Y.

The Following Bulletins are Available for Distribution to Those Who may Desire Them.

39 Creaming and Aerating Milk, 20 pp,
40 Removing Tassels from Corn, 9 pp.
41 Steam and Hot-Water for Heating Greenhouses. 26 pages.
49 Sundry Investigations of 1892, 56 pp.
53 Œdema of the Tomato, 34 pp.
55 Greenhouse Notes, 31 pp.
61 Sundry Investigations of the Year 1893, 54 pp.
64 On Certain Grass-Eating Insects, 58 pp.
69 Hints on the Planting of Orchards, 16 pp.
71 Apricot Growing in Western New York, 26 pp.
72 The Cultivation of Orchards, 22 pp.
73 Leaf Curl and Plum Pockets, 40 pp.
74 Impressions of the Peach Industry in N. Y., 28 pp.
75 Peach Yellows, 20 pp.
76 Some Grape Troubles in Western N.Y., 116 pp.
77 The Grafting of Grapes, 22 pp.
78 The Cabbage Root Maggot, 99 pp.
79 Varieties of Strawberry Leaf Blight, 26 pp.
80 The Quince in Western N. Y., 27 pp.
82 Experiments with Tuberculin, 20 pp.
84 The Recent Apple Failures in N. Y., 24 pp.
87 Dwarf Lima Beans, 24 pp.
92 Feeding Fat to Cows, 15 pp.
93 Cigar-Case-Bearer, 20 pp.
95 Winter Muskmelons, 20 pp.
96 Forcing House Miscellanies, 43 pp.
97 Entomogenous Fungi, 42 pp.
101 The Spraying of Trees and the Canker Worm, 24 pp.
102 General Observations in Care of Fruit Trees, 26 pp.
103 Soil Depletion in Respect to the Care of Fruit Trees, 21 pp.
104 Climbing Cutworms in Western N. Y. 51 pp.
105 Test of Cream Separators, 18 pp.
106 Revised Opinion of the Japanese Plums, 30 pp.
109 Geological History of the Chautauqua Grape Belt, 36 pp.
110 Extension Work in Horticulture, 42 pp.
114 Spraying Calendar.
116 Dwarf Apples, 31 pp.
117 Fruit Brevities, 50 pp.
119 Texture of the Soil, 8 pp.
120 Moisture of the Soil and Its Conservation, 24 pp.
122 Second Report upon Extension Work in Horticulture, 36 pp.
123 Green Fruit Worms, 17 pp.
124 The Pistol-Case-Bearer in Western New York, 18 pp.
125 A Disease of Currant Canes, 20 pp.
126 The Currant-Stem Girdler and Raspberry-Cane Maggot, 22 pp.
127 A Second Account of Sweet Peas, 35 pp.
128 A Talk about Dahlias, 40 pp.
129 How to Conduct Field Experiments with Fertilizers, 11 pp.
130 Potato Culture, 15 pp.
131 Notes upon Plums for Western New York, 31 pp.
132 Notes upon Celery, 34 pp.
133 The Army-Worm in New York, 28 pp.
134 Strawberries under Glass, 10 pp.
135 Forage Crops, 28 pp
136 Chrysanthemums, 24 pp.
137 Agricultural Extension Work, sketch of its Origin and Progress, 11 pp.
138. Studies and Illustrations of Mushrooms: I. 32 pp.
139. Third Report upon Japanese Plums. 16 pp.
140. Second Report on Potato Culture. 24 pp.
141. Powdered Soap as a Cause of Death Among Swill-Fed Hogs. 12 pp.
142. The Codling-Moth. 72 pp.
143. Sugar Beet Investigations. 88 pp
144. Suggestions on Spraying and on the San José Scale. 20 pp.
145. Some Important Pear Diseases. 36 pp.
146. Fourth Report of Progress on Extension Work. 28 pp.
147. Fourth Report upon Chrysanthemums. 36 pp.
148. The Quince Curculio. 28 pp.
149. Some Spraying Mixtures. 8 pp.

Bulletins Issued Since the Close of the Fiscal Year June 30, 1898.

150. Tuberculosis in Cattle and its Control.
151. Gravity or Dilution Separators.
152. Studies in Milk Secretion.
153. Impressions of Fruit-Growing Industries.
154. Table for Computing Rations for Farm Animals.
155. Second Report on the San José Scale.
156. Third Report on Potato Cultnre.
157. Grape-vine Flea-beetle.
158. Source of Gas and Taint Producing Bacteria in Cheese Curd.

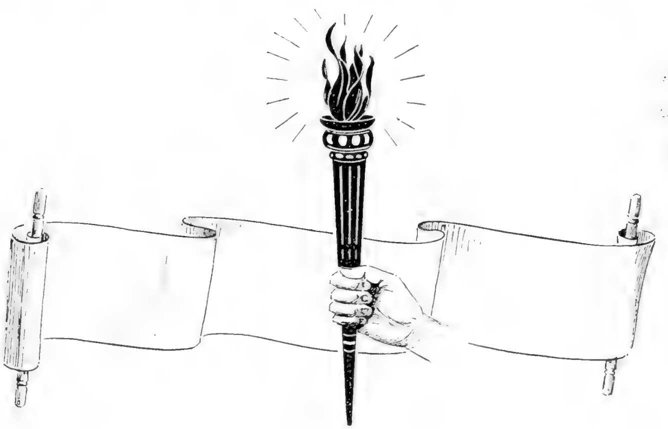
Bulletin 159. **January, 1899.**

Cornell University Agricultural Experiment Station,

ITHACA, N. Y.

AN EFFORT TO

HELP THE FARMER



Being the Fifth Report to the Commissioner of Agriculture of Progress of Work done under Chapter 67, Laws of 1898 (the Nixon Bill), to Promote the Extension of Agricultural Knowledge.

PUBLISHED BY THE UNIVERSITY.

ITHACA, N. Y.

1899.

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AN EFFORT TO HELP THE FARMER.

In 1894, the legislature asked the Cornell Experiment Station to endeavor to help the farmers by means of extension work. The request was unsolicited on the part of the University. In the same spirit, the request has been renewed by subsequent legislatures. The gist of the present law is to the effect that the College of Agriculture shall aid the farmer by means of experiments with crops and farm-management, by investigations of special difficulties, by lectures, publications, schools, teaching, and by any other means which promise permanent and useful results. The farmers were thought to be suffering: What can be done for their relief?

The results of much of the work have appeared in 62 bulletins; and full special reports of progress have been made in Bulletins 110, 122, 137 and 146. The present report gives a cursory view of the entire movement; but the details are largely those of the work of 1898 alone. It must be remembered, however, that while the field-work of 1898 is completed, the full results thereof are still in course of elaboration and publication.

Our first effort, in furtherance of the request of the legislature, was to determine what needed to be done. There were many opinions as to the best lines to pursue. We therefore went to the farmers with meetings, schools, lectures, and personal inspection of their places; and thereby we found our bearings. The land-grant colleges had been established for more than thirty years, and the federal experiment stations for eleven years. The results of the efforts of these institutions had been most beneficent, and the general tone of farming had been elevated immensely thereby. And yet, we found it to be a fact that the majority of farmers had not been personally touched by these great enterprises. There seemed to be a lack of actual contact between the farming-body and the teaching-body; and this is due to the fact that much of the teaching and experimenting is necessarily too advanced to appeal to the general farmer. It became plain, therefore, that the purpose of the legislature could be best subserved by teaching the individual farmer in elementary

matters. Scientific knowledge is far in advance of even the best farm practice. The farmer must be awakened and educated: how?

I. THE PRESENT-DAY PROBLEMS.

On every hand, the farmer is beset with difficulties. Many of these difficulties are such as pertain to business, or are inherent in the social and economic condition of the times: these cannot be removed by the special teacher or experimenter. Very many of the difficulties, however, are such as pertain to the growing of crops and the raising of stock; to many of these we have given attention.

a. BULLETIN WORK.

By special investigations on the farms and at the central Station at Ithaca, an effort has been made to understand the nature of a given problem: then the summary conclusions are reported in an easy, readable, expository bulletin, in which graphic and truthful pictures are made a special feature. These bulletins are not mere essays. Every one of them has been the result of careful investigation and study by an expert; but, in most instances, the details of the investigational work have been omitted in order to relieve them of heaviness and technicality.

The usefulness of a bulletin often depends quite as much upon its attractiveness as upon its subject-matter. A "dry" bulletin does little good to most farmers, even though its teachings are of the utmost importance. The bulletin should be well printed, handsomely illustrated, and, above all, well edited. It should be timely. The effect of many a good bulletin is nearly lost because it is delayed until the need for it has passed. It must be remembered that the experiment stations exist to help the farmer, not the scientist.

Although this extension work has drawn heavily upon the time and strength of the staff, bulletins from the regular federal fund have been as numerous as they were before the Nixon law was enacted, considering the fact that the income from the federal fund is $1500 less than it was then. From the beginning of 1894, 36 bulletins have been issued from the general federal fund.

Fruits.—The fruit interests received the first attention, because the original act of the legislature so requested. There was also great fitness in this, because these interests are relatively new, they are beset by many special difficulties, and there is a strong tendency to forsake the old-line farming for fruit-growing. There is also a rapidly growing demand for instruction in such special businesses as flower-growing and glass-house gardening. In a preliminary and educational way, nearly the entire field of New York fruit-growing has been worked over ; and thenceforth the fruit-farmer needs new instruction in special problems rather in the great underlying principles. Two of the horticultural investigators have been to Europe (at their own expense) and have made particular studies of similar problems there ; and the New York fruit-grower has had the benefit of these observations in bulletins and lectures.

Of bulletins relating to fruit-growing interests, including insects and diseases, 35 have now been issued under the Nixon bill. Some of the subjects are as follows :

Hints on the planting of orchards.
The cultivation of orchards.
The peach industry in New York.
Grape troubles.
Grafting of grapes.
The quince.
Failures in apple-growing.
Blackberries.
Raspberries, and evaporating them.
Plums in New York.
Japanese plums.
Strawberries.
Dwarf apples.
Apricot-growing.
Cherries
Care of fruit trees.
Soil depletion in orchards.

Insects, fungi.—Special efforts have been made to check the spread of the most injurious insects pests and plant diseases. Experts have been sent to investigate serious outbreaks. Orchards have been sprayed, mass-meetings have been called to

give instruction in spraying, and much literature on the subject has been circulated.

Of separate bulletins in this direction, 16 have been issued. Some of the subjects are the following:

Peach yellows.
Black-knot of plums and cherries.
Plum scale.
Spraying (several reports).
Cigar case-bearer.
Climbing cutworms.
San José scale (two bulletins).
Diseases of potato.
Diseases of pear.
Quince curculio.
Canker-worm.

Vegetables, flowers. — In vegetable-gardening and flower-growing, 14 separate bulletins have been published, some of which are:

Lima beans (two bulletins).
Celery.
Winter muskmelons.
Chrysanthemums (four bulletins).
Sweet peas.
Forcing-house miscellanies.
Planting of shrubbery.

Sugar beets, potatoes, fertilizers. — Extensive experiments on sugar beets have been undertaken, as reported in Bulletins 143 and 146; and another bulletin is now ready for the printer.

Potatoes are now receiving attention. Bulletin 113 considers the diseases of potatoes. Very striking results have been obtained with the cultivation of potatoes on the Cornell farm, but the reports have been published from the regular Experiment Station fund. (See Bulletins 130, 140 and 156). As explained farther on (p. 248) these experiments are now to be extended over the State.

Extended experiments on fertilizing the land have been conducted during two years, beginning with the issue of Bulletin 129. Experiments of this kind mature very slowly, but forthcoming bulletins will give full results of the work.

Animal industry.—The results of investigations into the cause of "gassy curds" in cheese are published in Bulletin 158. Other subjects pertaining to the dairy and animal industry have received attention, and the results are now practically ready for publication.

In general.—The popularity of the bulletins has exceeded all expectations. New editions have been made of several of them, and three (Nos. 119, 120, 121) have been reprinted five times. Our mailing list is frequently revised in order to cut off all dead and dormant names. The list is a "live" one; and yet of the 62 Nixon bulletins, 907,000 copies have been issued, comprising 679 illustrations and 1880 pages.

b. UNPUBLISHABLE WORK.

Only a part of the work of any Experiment Station can be published. Perhaps half its energies is consumed in correspondence, giving personal advice, attending meetings, making records, and the like. Nor is it desirable that all its experimental work be published, particularly if it is conducted in different parts of the State. The value of an experiment often lies in the fact that it is an object lesson, and that it sets the people of any community to thinking. An experiment in fertilizing potatoes, for example, may be of the greatest value to a community and yet not produce results which are new to science and worthy of publication. The experiment, in other words, may have inestimable teaching value. The farmer may read that spraying is necessary. He may even understand how to perform the operation. But he really does not believe in it until he sees it done and watches the results. If the bulletin is a means of conveying information to the farmer, certainly the itinerant experiment is another means. In fact, the experiment may be the more efficient means; but it cannot be taken to so great a number, and it is relatively much more expensive.

Of all the means of reaching the grown-up farmer, the personal visit to his place is the most efficient. He has a hundred questions in mind. Some of these are settled for him when the Experiment Station officer comes. He looks forward to the visit; and then he looks back upon it and is conscious that

new ideas have taken possession of him. He has been touched, and farming will never be quite the same to him thereafter.

This personal contact of teacher and farmer is one of the best results of our scattered experiments with sugar beets and fertilizers. The inspector goes to see the experiments ; but he knows that many other questions will come up. For example, our agent who inspected the fertilizer plots, carried litmus paper for the purpose of testing acidity of soils. During the past season, he made 179 such tests ; of these, 154 gave decided acid reactions. The nodules on clover roots, the way to make Bordeaux mixture, how to drain a field, what is the matter with a cow, why the hens do not lay, the value of a new strawberry, how to handle a weed,—the questions are legion. The inspector will not be able to answer them all, but he can answer some of them. But, better than answering, he can suggest how the farmer can find out for himself.

It is a pity that every farmer in the State cannot be personally touched at least once in his life by the methods and the inspiration of a good teacher. One section of the State could be taken at a time, and a patient, quiet, honest, sympathetic teacher could visit every farm for a few hours or a day. It would pay.

C. INVESTIGATIONAL WORK NOW IN HAND.

The investigational work comprises experiments proceeding at Ithaca, and also in many parts of the State. Some of these, as fertilizer studies, are long-time subjects, and cannot be reported in full at the close of the first or second year's work. Of several of these investigations, reports may be expected during the present winter. Many minor investigations are not mentioned here. They are such as are of very secondary importance or which apply only to limited areas, or which have been taken up at the request of some local society or organization.

Sugar beets.—In accordance with arrangements made with the State Department of Agriculture at Albany, and the State Experiment Station at Geneva, the Cornell Station conducted experiments in 1898 with sugar beets in the following counties : Niagara, Orleans, Monroe, Genesee, Livingston, Wyoming, Erie, Chautauqua, Cattaraugus, Allegany,

Steuben, Chemung, Tompkins, Tioga and Broome. In these counties, 1,113 pounds of beet seed were distributed to 417 farmers; and 21 one-pound lots were distributed to applicants outside these counties. Thereby, 438 farmers were connected with the work, and 1,134 pounds of seed were distributed. Of these farmers, 40 received fertilizers for use on the beets, 45 sacks having been used in this distribution. The sugar beet expert visited about 120 of these farmers to arrange in person the preparation for the experiments. Subsequently, he inspected 125 of the growing plots. Aside from this, about 50 commercial plantations were inspected.

Two circulars were issued to the sugar beet experimenters. One (No. 15) explains in detail the methods to be employed in raising the beets. The other (No. 17) gives instruction in methods of sampling, and was accompanied with blanks for the reporting of the results of the work. These circulars will be given to the public in the forthcoming report on sugar beets.

The chemical work on this sugar beet investigation has been heavy. A total of 490 complete analyses has been made, comprising determinations of solids, sugar in juice, and purity.

Experiments are in progress on the feeding value of sugar beet waste.

The full report of the work of 1897 on the sugar beet was published as Bulletin 143. A bulletin will soon be issued on the work of 1898.

Fertilizers.—In 1897, 203 farmers coöperated in field experiments with fertilizers (see Bulletin 146, p. 639). In 1898, 100 farmers were selected to continue the work. In March, a circular (No. 13) was sent to the correspondents, giving specific directions, with diagrams, for carrying on the work. This instruction was supplemented by another and very explicit circular (No. 14), which also included blanks for the making of reports. A revision of Bulletin 129 ("How to conduct field experiments with fertilizers") was also sent to each correspondent.

The 100 experimenters live in 39 counties and 95 postoffices. During the past summer, the fertilizer expert visited 75 farmers at 69 postoffices in 25 counties, and gave specific instructions on the work.

Whenever it seemed to be necessary, samples of soil were taken for analysis. Of these, 38 samples are now being analyzed. In the fertilizer work, there had been made to December 10, 1898 :

76 determinations of nitrogen.
42 determinations of total phosphoric acid.
42 determinations of total potash.
14 determinations of potash by official methods.
14 determinations of phosphoric acid by official methods.
14 determinations of available potash in soil.
14 determinations of available phoshoric acid.

Experiments on some of these soils, with growing plants, are now proceeding under glass.

It is expected that the results of this two years' work with fertilizers will be published during the present winter.

Aside from these general fertilizer investigations, the Horticultural Department has been making similar studies along special lines for a number of years ; and the results now await publication. This undertaking has also involved much chemical work. These investigations have been made in

Nurseries.	Strawberry plantations.
Vineyards.	Currant bushes.
Apple orchards.	Field beans.
Peach orchards.	Celery.

Potatoes.—Such remarkable results in potato growing have been secured during the past three or four years on the Cornell Experiment Station grounds, that it has been thought desirable to test the methods employed here to ascertain whether they will give similar results on other soils and in other hands. It is hoped, also, by having the tests made by the farmers themselves on their own farms, to attract the attention of potato growers throughout the State, more emphatically than it has been possible to do by the work done at the Station.

The land used for these experiments at the Station is a gravelly soil which analysis has shown is carrying little more than half the potential plant-food found in average soils. (See Bulletin 130, p. 157.) It has not been manured or fertilized since the autumn of 1893 (see the same, p. 157), and has produced heavy crops of grain or forage each season till planted to potatoes. (See Bulletin 135, pp. 277, 287.)

In 1895, eight plats averaged at the rate of 352.6 bushels, ranging from 304 to 415 bushels, according to treatment. That year was especially favorable for potatoes and the average for the State was extra high, being 122 bushels per acre. (See Bulletin 140, p. 389.)

In 1896, nine plats averaged at the rate of 319.4 bushels, ranging from 245.8 to 350.3 bushels. The average yield of potatoes in New York for that year was 89 bushels per acre. (See Bulletin 140, p. 389.)

In 1897, ten plats averaged at the rate of 322 bushels per acre, ranging from 234 to 384 according to treatment. The average in the State for this year was 62 bushels per acre. (See Bulletin 140, p. 390)

The experiments of 1898 were similar to those of 1897, and are described in Bulletin 156. The average yield of eleven plats was 292.3 bushels, ranging from 206 to 398.6 bushels, according to treatment.

A circular (No. 18) has now been issued, asking for volunteers in potato experiments. So far as possible, these investigations will be given to those who have taken active interest in the Reading-Course. Favorable responses are now coming in.

Beans.—The field bean interest in New York is very large The Horticultural Department has made some study of it in previous years (p. 248), and it is now proposed to take up the subject more actively. During the past season, a preliminary study has been made of the subject. Pot experiments are now in progress under glass to determine if soil needs to be stocked with specific bacteria in order to produce beans.

Dairy.—During the year, a full investigation has been made of the causes of gassy fermentations in milk, and the results have appeared in Bulletin 158.

Complaints having been made of poisonous cheese coming from a certain factory, the matter was investigated in connection with the State Department of Agriculture. Our cheese maker and bacteriologist were sent to the factory. As soon as our cheeseman took the cheese-making in charge, the poisonous product ceased. The causes of the infection, while not thoroughly under-

stood, are sufficiently known to enable us to publish a report on the subject before spring.

A rather full survey has been made of the condition of the creameries and cheese factories, and the results now await publication in bulletin form (page 254).

Very extensive tabulations of the results of dairy work at Cornell are now being completed, and the summary results may be expected at no distant day.

Veterinary science. — The State Veterinary College now has under investigation, for the Nixon bill, the causes and treatment of contagious abortion in cows.

Horticulture.—Experiments in the fertilizing of strawberry fields have been progressing for three years in Oswego County, and it is designed that they be continued. Preliminary results may be published the present winter. Other experiments with fertilizers are now practically ready for reporting (page 248).

For two years experiments have been conducted in Orange County to determine if celery can be profitably grown on the extensive bottom lands which were formerly used for onions. It has been demonstrated that celery can be raised there with success.

All the extensive fruit interests of the State have been and are constantly under review, and special reports may be expected from time to time. A general review of the fruit-growing business, drawn from long-continued observations in this country and abroad, has recently been published as Bulletin 153. Inspection of orchards for yellows and other diseases, and the giving of personal advice wherever requested, have always been prominent features of the horticultural work.

At Ithaca, the study of Japanese plums (on which three Bulletins have now been issued) is to be continued. A very large collection of these fruits is now growing on the University ground. Studies are also progressing in pruning and on the fertilizing and tilling of fruit lands. Upon this subject of tilling, three or four reports have already been issued, and others may be expected as the tests mature.

The winter forcing of strawberries was reported in Bulletin

134, this being the only bulletin on the subject which has yet appeared in this country. The experiments are continuing, and another report is forthcoming. The subject of forcing-house crops has awakened so much interest, that experiments are now in progress with the forcing of peaches, apricots, nectarines, pears and apples.

A particular study of mushroom growing has been in progress for two years.

In flower-growing the investigations have been rather extensive. These inquiries have two general objects,—to give information to commercial flower-growers, and to interest the people in home-making. The latter purpose is further discussed in Part II.

Chrysanthemum culture has now received attention for five years, and four bulletins have been issued. Another report may be expected soon. Annual flowers have received attention for two years, over 400 species and varieties having been grown. A bulletin on the subject (No. 161) is now on the press. Dahlias, sweet peas, bulbs, carnations and other flowers, are or have been subjects of special investigation.

Extended tests have been made of sweet corn, Brussels sprouts and other vegetables ; and some of these are still continuing.

Other horticultural work is considered in Part II.

Insects.—Nine special bulletins have been published by the Entomological Department in the Extension work, and the Department has rendered valuable aid to the work of the Horticultural Department and others. Inspection of infested plantations is a very important part of the work and many minor insects are constantly under review. Aside from this work, the following subjects are now receiving particular attention :

Study of the peach-tree borer. This work has been progressing four years on a plantation of 450 trees set for this particular purpose. The compilation of the results will be completed before spring opens.

Canker-worms. In western New York, about 4000 acres of apple orchards were stripped by these pests in 1898. At least five different kinds of canker-worms are working in these orchards.

Tent caterpillars. Of these pests there are two species, the apple-tree tent caterpillar and the forest tent caterpillar. The latter often works with the former in apple orchards, but it is chiefly confined to woods, often defoliating sugar bushes.

Studies of insects preying upon shade trees in cities and villages.

Plant diseases. — Several bulletins and parts of bulletins have already been devoted to diseases infecting crops. Plantations are inspected by the mycologist. During the past season there has been an unusual correspondence relative to onion and celery diseases, leaf-curl of the peach and blight of the pear. In addition, the following special topics are now under investigation :

The three most important fungous diseases of the sugar beet in this State will be discussed in a bulletin now almost ready for the printer. Beet rot has received special attention and interesting results have accrued, showing the connection of this fungus with certain diseases common in the greenhouse.

A rot of greenhouse tomatoes has been the subject of considerable experimentation ; and experiments now in progress will doubtless complete a determination of the conditions which induce the disease.

Spraying peach trees for the leaf-curl has yielded satisfactory results ; and the whole matter of the effect of Bordeaux mixture on peaches, plums, etc., will be discussed in a bulletin to be published in time for the direction of fruit-growers in 1899.

Chrysanthemum rust, dracæna leaf-blight, and a blight of seedling red cedars, have received special attention among the diseases of ornamental plants.

d. ITINERANT TEACHING.

Aside from all this work of investigation and publication, the people have requested instruction by teachers who shall be sent into their community. In the early days of the Extension work, many such schools were held, and they are fully reported in Bulletins 110 and 122. At the time, these schools were looked upon as means of determining the needs of the farmers and the most efficient methods of reaching them. The officer in charge

of these schools reported as follows in Bulletin 122: "As a result of the holding of many of these schools, I am now of the opinion that they cannot be used as primary factors in university extension; they are capable of accomplishing a great amount of good when the community has been awakened by simpler and more elementary means. I should therefore consider that they could serve their best uses when they are given as a reward to those communities in which the greatest amount of interest in reading courses, in horticultural clubs, institutes and such other public factors has been developed. There are centers enough in New York State where such schools can be held with distinct advantage at the present moment; but they should be the culmination of a series of extension teaching efforts rather than a primary or preliminary means of awakening the rural communities."

With this sentiment we still agree. The larger part of our work can be done more economically than by the holding of schools. Yet, these schools are of the greatest value in particular places and cases. During the present winter we have decided to hold ten of them, locating them, so far as possible, in places in which the Reading-Course has made some progress. At this writing, four of these schools have been held, in Niagara, Saratoga, Cattaraugus and Genesee Counties.

In these schools, an attempt is made to teach the fundamental principles of the given subject,—that is, to educate the participants. One session is devoted to one topic, and this is placed in the hands of an expert in that subject. These schools do not in any way conflict with the Farmers' Institutes, but are rather supplementary to the work which they are doing. We believe that the Institutes have done and are doing the greatest good to the farming interests, and the itenerant schools are in no sense rivals of them.

Special dairy schools have also been held during the past summer in factories at Ox Bow, Somerville, Hannibal, Houseville, Carthage, Windecker, McGraw, Windsor, Lyons, Willink, North Cuba, Canisteo and Belfast. These were largely in the nature of practical demonstrations.

A dairy instructor was also sent to cheese factories and creameries in the following counties: St. Lawrence, Franklin, Clinton

Washington, Montgomery, Oneida, Onondaga, Cayuga, Broome, Chenango, Cortland, Steuben, Alleghany. About 75 factories were visited. A report upon these factories will soon be published in bulletin form (see page 250).

Aside from these schools and inspecting tours, the members of the staff are in demand as lecturers before various rural societies and meetings. Such demands consume much time and energy.

II. THE RISING GENERATION.

"My ducks are dying. Please tell me what to do." This is the gist of an inquiry received at the Experiment Station a few days ago. This type of appeal is common, and of course we cannot help the questioner. The difficulty is that the person does not observe closely, does not search for causes, does not see the world intelligently. He does not know a duck; or if he thinks he knows it, he does not see it. All this failure is the fault of his early training: the person was not educated.

However much we may experiment and teach the farmer, we are not striking at the root of the rural problem. We must begin with the child. Teaching the grown-up farmer is productive of great good, but the crop of grown-up farmers is constantly recurring. The time to educate is when the person is young. Education is then more efficient and cheaper. The first course in our chimney should be laid at the bottom, not at the top.

As the result of five years of effort and enquiry, we now believe that we should endeavor to help the farmer in every way possible in his present-day difficulties, by means of experiments, investigations, bulletins, itinerant schools, institutes, inspection of his place, but that the greatest and most persistent effort should be expended in training the rising generation. The only complete and permanent success is that which takes hold of the very root of the difficulty.

We assume that every one will agree with this proposition. The only discussion will come on the means of touching the rising generation. How shall we reach the children? To this question we have given much thought, and every scheme which

has been suggested has received careful consideration. Our conclusion is that the most efficient way of reaching the young is through what we call nature-study.

It is commonly said that agriculture should be taught in rural schools. This may come in time with the older scholars; but the first thing to be taught is how to see, how to reason from what one sees, and to love and appreciate the natural world. That is, the first thing is a training nature-ward; later the training may be applied to specific problems, to farming. Again, there are very few teachers who are competent to teach agriculture in the common schools, even if they had a good text-book. We must teach the teacher as well as the pupil. Still again, the primary school is not the place in which to teach trades and professions. We do not teach law or medicine or engineering in the common schools: these are subjects to be taken up after the pupil has had good mental training. There is little use in telling a pupil about duck-raising until he knows a duck.

In the hands of most teachers, the teaching of agriculture would be instructing in mere ways of doing things, but this is only the giving of information; it is not education. How to plant potatoes, when to cut corn, the best variety of wheat,—these matters do not interest children particularly, and they are different for every different year and locality. The real things to teach are why potatoes should be planted so and so, why corn should be cut at a certain stage of its maturity, what are the principles which underlie the selection of a variety of wheat. These matters are fundamental in every season and in every locality. The pupil is taught to think out the problem for himself. But where are the teachers to do this work? Certainly not in the country schools, for the country schools have the poorest teachers.

a. NATURE-STUDY.

The outgrowth of our present nature-study methods from the itinerant schools of horticulture and the visiting of rural schools, is set forth in Bulletins 122 and 137. The nature-study work is progressing along several lines, each of which may be mentioned.

Leaflets.—In order to interest and instruct teachers in the objects and methods of nature-study the following leaflets have now been issued :

1. How a squash plant gets out of the seed, 5 editions.
2. How a candle burns, 6 editions.
3. Four apple twigs, 6 editions.
4. A children's garden, 7 editions.
5. Some tent-makers, 7 editions.
6. What is nature-study, 6 editions.
7. Hints on making collections of insects, 3 editions.
8. The leaves and acorns of our common oaks, 5 editions.
9. The life-history of the toad, 4 editions.
10. The birds and I, 4 editions.
11. Life in an aquarium.

The number of editions is some indication of the popularity of these leaflets ; but a better measure of their usefulness is shown by the fact that 22,000 teachers have made written requests for them, and 2,816,000 pages of nature-study leaflets have been printed. Aside from this, there is a demand from other States in larger lots,and these our printer is authorized to supply at low rates. He has sold about 5000 copies in 33 States and Provinces.

Applications for these leaflets are now coming in at the rate of about 250 a week. The following table shows the number of requests received for the leaflets for the 10 weeks ending Dec. 10, 1898 :

											Total.
Monday	51	39	63	45	26	28	29	27	46		
Tuesday	51	29	37	32	41	31	24	18	28		
Wednesday	61	40	55	39	15	35	37	54	28		
Thursday	36	21	49	15	94	41	38	17	17	300	
Friday	31	34	23	43	56	57	69	11		37	
Saturday	32	46	25	38	32	25	38	176		61	
	262	209	252	212	264	217	235	303	119	398	2471

Other leaflets are in preparation. However, it is not our purpose to issue a great number of subjects, but to press home every leaflet to the full possibilities of its usefulness. By personal work with teachers, and by correspondence with school officers, tachers and pupils, these leaflets are brought to the attention of those for whom they are written. In this effort, 80,000 circular letters have been distributed.

Following is a sample letter to a teacher :

Egg-shell farming is a very fascinating method of interesting lower-grade pupils in plant life. Egg-shells from the breakfast table are available for the purpose. If broken well towards the small or taper end of the egg, greater capacity for earth and root-growth will be afforded. A small hole should be made in the bottom of the shell, for drainage. Potting-earth from the florist's will probably be the most available source of supply for schools in densely populated districts. Whenever practicable, field excursions for such a supply will add much to the interest of the pupils, and the opportunity for observation can be made of great value as well. Any bit of woods or thicket, where the wind has for years driven the leaves and left them to rot, gives good material for this purpose. Rotted leaves mixed with soil should be chosen, and not rotted leaves alone. We suggest that the child be instructed to fill the shells with soil and plant the seeds, for the more he does in the undertaking the greater will be his interest. He should be made to understand that the shells he fills and plants are his farms, and he must write his name on them for identification. After being filled, planted and labelled, the shells can be massed in a window-seat for watering and light. They can be distributed to the desks of the owners for study and admiration whenever the teacher desires. The spirit of emulation for best results in plant growth can be engendered among all the egg-shell farmers. The question of the number of shells that shall be allotted to each pupil can be left to the discretion of the teacher. The variety of seeds that can be sown to advantage is very general, but if the teacher feels the need of aid in the undertaking, we suggest that squash seed be planted and that our Leaflet No. 1 ("How a squash plant gets out of the seed") be consulted. The fact that the capacity of the egg-shell will not take the plant to maturity need not be deplored. Children like change, and the life-history of nearly all plants covers a period too long for maintaining a juvenile interest on a high key. It is better to have change and to carry on the study by sections. Logical connection is more practical in the higher grades.

If for any reason you are disinclined to take up any feature of nature-study, and you have some pupils who have such a desire, we will appreciate the courtesy if you place us in communication with them for correspondence.

Home-making.—Some of these leaflets are designed to appeal to the home as well as to the school. It is the attractive and happy rural home which first and chiefly interests the child in rural life. A neat lawn or a flower-bed is more likely to influence the child to love country life than a good field of potatoes is. Predilections are formed earlier than we are aware. Money considerations do not appeal strongly to the child. He must be

interested on his intellectual and sentimental side. His eyes must be opened to the great world of interesting things all about him; for most persons "have eyes, and see not."

In this work of appealing to the home-making, we have issued various bulletins of which the chief is No. 121, "The Planting of Shrubbery." This bulletin has now gone to five editions, and the demand for it is still brisk. All our flower bulletins (page 244) are also designed to encourage the upbuilding of attractive home life. In furtherance of this idea, the Horticultural Department has been making an extended study of annual flowers for the past two years, and the results are on the press as Bulletin 161.

If the home should be attractive, so should the schoolhouse be. It is a marvel that all the children do not run away from the average rural school premises in sheer dread and disgust. Suggestions for improving these premises are contained in Bulletin 160, which is now nearly ready for distribution.

Organizing the children.—Every incentive is given the pupils to take up observation lessons and collecting for themselves. An efficient means to this end is some kind of an organization of the children. We are now attempting the organization of "Junior Naturalists' Clubs" in all school districts which take an interest in our work. The children write us, enrolling their names, and suggestions are sent them as to the proper work of such a club. We are just beginning this work, athough 6000 children in the State have been reached, and the list is growing rapidly. It is inspiring.

The following sample letter will convey an idea of the kind of work suggested to the children:

ITHACA, N. Y., Oct. 10th, 1898.

My Dear Boys and Girls:

You ask us how to become a member of our Cornell Junior Naturalists' Club.

In answer we would say that we want to begin in a very simple way. We presume that you are in a school and have a teacher who is willing to help you in every way that she can consistent with her school duties. Please ask her if there are not some other boys and girls in your school who also wish to become members; and if so, ask permission to bring into the schoolroom some tent caterpillars or some pollywogs, as are described in our Leaf-

lets Nos. 5 and 9. You can watch them every day. You will find that the hairy fellows which live in a tent have great appetites, but you must study their habits and learn how to feed them. You can watch them enlarge their tents as they require more room, and cast off an old suit of clothes when it becomes too small. You will also find it interesting to watch the polly-wogs develop their feet and lose their tails, and become hop-toads. Ask your teacher to allow you to make all the interesting things that you see the topic for your language lesson, and also for your drawing, if drawing is taught. You can send your papers to us and we will send you similar papers from other Clubs, and will consider you all members. If our talk in Leaflet No. 4 has inspired you to plant some seeds, you can tell us of your progress in that direction, also. This is not all that we intend to make of our Clubs, but this will be an easy way to make a beginning and to become acquainted. We desire to develop your ideas and power of observation more than your spelling and punctuation. When you have learned to think and to see what you look at, you will be better able to correct your English. Please do not feel afraid of us, but write us as you would to an old friend of whom you are very fond.

The problem of providing suitable literature for teachers is small as compared with getting them to take up the work. The horse is easily led to water, but it is not always easy to make him drink. The introduction of the Junior Naturalists' Club, which consists largely in exchange of written observations and drawings, has proved one of the best methods of inducing the teacher and children to make a start. The first step is the hardest. Some rural schools took this first step by gathering apple twigs and sending them to the children of much less favored schools. When the twigs were being packed, they were looked upon as brush; but when a capable teacher had brought out the points as contained in Leaflet No. 3, entitled "Four Apple Twigs," and the pupils had written compositions and had made drawings of what they had discovered and these had been sent to the donors, it was senseless brush no longer. It had a history of half a dozen years written upon it; and it was the old, old story,—a struggle for existence and the survival of the strongest.

More than 16,000 school children in this State have sent us their names in request for information on making gardens; and we have supplied them.

We should like to make it possible for every rural school to have a collection of insects; and for every schoolroom to be embellished with artistic pictures of farm scenes and farm homes.

Personal work at the Teachers' Institutes. — The greatest

results are secured by means of personal work with the teacher. In this enterprise, as in others, the Department of Public Instruction has efficiently seconded our efforts. An expert nature-study teacher has been employed to attend Teacher's Institutes. Since the middle of last March, when the present law went into effect, this teacher has attended 72 institutes, occupying an average of three periods in each. It is estimated that 14,400 teachers have been reached in this way. The teacher not only presents the claims of nature-study, but also the specific means by which it may be taught. Many teachers have a mistaken idea as to what constitutes nature-study. Some conceive it to be a translation or exaltation of the child's mind to such an altitude that he can be crammed with science from a book and retain it in such form as to be capable of giving a reflected light in examinations. Examination seems to be the test of the value of all things educational. Our conception of nature-study is that it should be so informal as not to admit of systematic examination. The central thought is to study the thing itself. Each day try to see something that was unseen the day before, and with every new thing ask the question, What does it mean and what is its function? Some examples of nature-study work are now given to show the possibilities of this type of teaching:

The head of a burdock can be picked up. Perhaps the hooks were never before closely examined. Describe them minutely and make a drawing of the seed and hook. Of what use is the hook? When a child learns the functions of parts of vegetable and animal life, the keenest interest is incited. After the children of Corning had made collection of seeds and classified them upon their methods of dissemination, no hard drill was required to learn the names. After a boy has read "Robinson Crusoe" his geography of the island of Juan Fernandez is very accurate or easily acquired. Interest is the first point. No child is proof against the charm of a story. In the lower grades, the study of the things themselves may be idealized and personified. This can be overdone and made mere sentimentalism. Personification is necessary to kindle an interest, but it need not always be continued. As the child grows older and his powers of observation and reasoning become trained, the process can be intensified so that by the time the intermediate grade has peen passed he will be practically studying pure science. Our observation is that, in the graded schools, we get the most spontaneous work from the fifth, sixth and seventh grades.

Nature-study is not the teaching of science, not even of elementary science. It is seeing and understanding the common objects of the external

world. The high school pupil and the college student may study botany ; but the child should study plants. It need not necessarily be a stated part of the curriculum. In fact, with a good teacher it is all the better if it is spontaneous.

Nature-study can often be made a corollary of the geography, drawing, or language. For example, during the language period, the children in the sixth grade of one of the Saratoga Springs schools had some of their nature-study work for the topic of their compositions. In this instance wheat had been sown in egg shells, filled with earth obtained at the florist's, and each egg shell was a pupil's farm ; and he eagerly watched the germination of the seed in his wheat field until the blades had attained a height of two to three inches. Here the botanical side was made a lesson, well flavored with active interest. The pride of ownership and a plant coming from a spoonful of earth had the charm of a creation all his own, and it was much more real to study the thing itself than to read about it and to make a recitation. The lesson was well inculcated that the first shoots of root and stalk had to subsist on a lunch of starch, prepared by the parent plant, until the plantlet springing from the kernel could obtain its own living from the soil and air, and that these starch lunches give wheat and other grains a commercial value. The interest is now awakened in the necessity that the farmer should prepare a fine seed-bed in his soil, and in the details of sowing, harvesting and milling. Some of the diseases and insect enemies of the wheat plant can be taken up and will be retained by the child because he has an interest in a living thing. Drawings can be made of many of the stages of growth of the plant in the egg shell. Wheat can be made to correlate with the geography by tracing its introduction and extension and transportation. By means of the exchange of correspondence, the wheat belt can be traced and plotted in every State of the Union. The children, through their teachers, in the States of Texas, Alabama, Louisiana and Georgia have shown most hearty co-operation in the exchange of correspondence, telling of the leading agricultural products.

Again, the children of Corning, during September and October, gathered seeds and divided them into classes as indicated by the means of travel that nature had provided. Some seeds, for instance, travel by means of a balloon ; others catch onto passing objects, clothing, hair of animals, like tramps upon a passing freight train ; and some have rudders to guide them through the air. A small boy felt himself a profound investigator when he discovered the advantage that some seeds have because they can float and take a ride on the water. Two men were heard discussing the wonderful vitality of weed seeds found in soil taken from a well twelve feet deep, asserting that after the clay from the bottom had remained exposed to the action of weather for a year or so, the growth of a few weeds followed. The children of Corning, after their investigations, could very well tell where the seeds of the weeds came from.

The pupils of Jamestown write most interestingly of their experience in

summer planting of flowers. On the 23d of September the teacher in one of the grades had a flower show in her room.

Many interesting compositions and drawings have been received by children who had the tent caterpillar under observation during the spring months. In this case they rear the tiny caterpillar from the eggs, watch its growth during the larval stage and change of skins, see it go to sleep a crawling hairy creature,and after remaining a time a pupa, see it resurrected into a being with wings. This lesson, showing the four periods in the life-history of insects having a perfect metamorphosis, has shown the child what many learned judges and wise statesmen have never seen. We are in receipt of many creditable compositions and drawings showing the different transformations.

Nature-study can be made elastic. In the kindergarten it can be idealized so as to approach a fairy story. It can be intensified as the grades advance so that in the high school it will have all the solidity of pure science.

Summer schools.—The summer schools for teachers held by the Department of Public Instruction have been kindly opened to us for nature-study work. At the Chautauqua school last summer we supplied two teachers. The number of teachers who sought this instruction and performed laboratory work was about 80. The State Department also gave efficient instruction in similar lines.

At Thousand Island Park about 60 teachers took the work.

At the Ithaca school about 50 teachers were enrolled in nature-study work.

The best proof that the nature-study idea is bearing fruit is the fact that teachers are now asking for definite instruction in this subject. We are proposing, therefore, to offer a serious course in nature-study to school teachers at Cornell during the coming summer. This is probably the first specific nature-study school to be organized in this country. It has a special high-class faculty. It is designed to teach nature-study

in insect life,
in plant life,
on the farm.

General results.—Aside from all these means of pushing the nature-study idea, members of our staff visit teacher's organization, by request, and write for the press. We have also had the coöperation of many leading educators in all parts of the country. In fact, the enthusiasm with which the work has been

received by those best capable to judge of its defects and merits is a constant surprise to us.

One of the most gratifying of these encomiums is contained in the last official report of the Honorable James Wilson, Secretary of Agriculture. He not only outlines the Cornell work specifically, but also makes the following very significant remarks on nature-study in the common schools :

"There is growing interest in education that relates to production. All classes of intelligent people favor it. Congress endowed colleges to teach it, and progress is being made, but not so rapidly as the growth of our country demands. More knowledge concerning what the farmer deals with every day would enable him to control conditions, produce more from an acre, and contribute more to the general welfare. The education of our people in common school, high school, and college has not been designed to prepare them for producing from the soil, excepting the very few who have found their way into our agricultural colleges. It is evident to educators in agricultural science that elementary study should be introduced into the common schools to give direction early in life.

"Agriculture, horticulture, forestry, gardening, and landscaping are delightful studies that attract people in all walks of life, but there is enough to be learned regarding each of these to require the devotion of a lifetime. The colleges and experiment stations endowed by the Federal Government provide for training along this line for longer or shorter periods at the institutions of the several States and Territories designed for this purpose ; but while encouraging progress has been made in building up courses in these institutions that teach the sciences relating to production, instruction before going to college and after graduation is lacking. Nothing is being done in most of the common schools of the States to cultivate a taste for and lead the mind to inquire into and store up facts regarding nature, so that the young farmer may be directed into the path that leads to education concerning his future life work."

The following letter is from A. E. Winship, Boston, editor of

the *Journal of Education*, and one of the leading educational critics of the day :

> Permit me, in thanking you for a set of the Nature-Study Leaflets, to say, from a fairly complete knowledge of what is being done educationally throughout the country, that there is no attempt through the schools to give a knowledge of nature and love for it that will compare for a moment in efficiency with the New York plan. It is intelligent, comprehensive, practical. The information is reliable—which is of prime importance—the presentation is interesting, and everything is adapted to the schools, even to untrained teachers.
>
> The influence of this work is being felt in the teaching of other subjects, so that Nature-Study, under the patronage of the State, has a mission in many phases of school work.

It was our first thought and effort to introduce the nature-study into the rural schools. But the strictly rural school is the most difficult to reach. The number of pupils is usually small and largely of the younger class, and patrons are easily led to believe that economy lies in employing a cheap teacher (commonly $5 to $6 per week), which means a teacher having minimum qualifications. If perchance an apprentice is employed and she shows enough progressiveness to take up nature-study, it is not long before this is recognized and better wages are offered by the village or town school, and she ceases to be a rural teacher.

Great educational movements are formulated and promulgated in the cities. They are copied by the villages and hamlets, and some of the impulse finally finds its way into the rural district school. We were therefore obliged to cast our pebble in the center of the pool and let the ripples work outwards. The cities took up the work with enthusiasm and often with avidity. We now begin to see the fulfillment of our hopes, for this year the requests for leaflets are coming mostly from the villages and cross-roads.

A year ago the nature-study work was still in its experimental stage, but we now feel that the greatest difficulties have been overcome. Nature-study will not revolutionize the world, but we believe that it is the most efficient single agency recently devised of affording permanent relief to the farming industries. It is natural, simple, fundamental, attractive. We are convinced that this enterprise alone is worth all the energy and money which has been devoted to the extension work.

b. THE READING-COURSE.

Every person is certain that a systematic course of reading would be productive of the greatest good to the farmer ; but only those who have tried to establish such a course know how difficult the task is. Those farmers whom it is chiefly desired to reach are not ready for books. It is said that book writings are too technical, but technical matter must be presented largely in technical language. Merely dropping technical terms is only a cheap means of writing in a popular way. The trouble is that the farmer does not think in books. He has not been trained in that way. The matter must be written from his standpoint and be digestible. It must be peptonized.

Our first effort to establish a reading-course was the recommendation of a set of books and bulletins (see Bulletin 122, p. 494). It did not work.

Last winter we devised a different plan. The purpose has been two-fold, — to charge the reader with information concerning his occupation, and to incite him to thought and observation. This we undertake to do by a process of pouring in and pumping out The subject for the winter of 1897–'98 was texture of the soil and conservation of moisture. A preliminary class of 1,500 was enrolled the winter before, and 5,000 during the winter of 1897–1898. In serving this class, 280,000 pages of literature were distributed free. The interest shown by the members has been so eager and intelligent that we have decided to give this feature of University extension work more attention than ever before.

The plan for the present winter is to divide the work into five subjects, three on soil and two on plant life. Very little attention will be given to the handicraft or the how of farming. Farmers have a very fair understanding of this ; but the why, the philosophy of cause and effect, a correct understanding of which will enable the farmer to act on a principle and not on a recipe —, these things are not understood.

The following circular (Nov. 15, 1898) will set the reading-course problem, as we see it, before the reader :

"I. WHAT IT IS.

"The object of this Reading-Course is to instruct farmers in thinking out their problems for themselves. Therefore, a problem is set, and the solution is suggested. Then the reader is requested to send us his answers and

to ask any questions respecting the subject. It is not enough to read: one must think and ponder upon what he reads. Therefore, an indispensable part of a reading-course is the question and the reply.

"We want every reader to answer the questions for himself. We are after results; therefore we are not looking at the handwriting, nor the grammer, nor the spelling. Write us the questions which are troubling you, and we will do our best to give you a direct, personal and satisfactory answer. The persons who answer these questions are themselves farmers, and appreciate your efforts.

"This Reading-Course is maintained by the State (the Agricultural Extension or Nixon fund) and is therefore free. It will be conducted until March. Thereafter, the busy season will compel us to cease. We must therefore take it up with a will.

"II. HOW TO MANAGE IT.

"We expect to issue about five Reading-Lessons during the winter. We expect that one lesson will be sufficient for one month. Three lessons will be devoted to the soil.

"The first Lesson will be sent to all persons who were on our Reading-Course list last winter, and to any others who may apply or whose names are sent us. All those who reply to the questions in this first Lesson will be put on our permanent list.

"The best way to get the good of these Lessons is for the readers in any community to meet together (perhaps at some one's house) once a month. The Lesson is read by each party at home; then it is thoroughly discussed at the meeting. We can occasionally send a man or agent to such meetings to give instruction; but the agent will be sent only to those places in which the attendance has been the greatest and the replies to our inquiries have been the fullest.

"Read the Lessons carefully and critically. Test every statement by your own experience. Some of the statements are framed purposely for the bringing out of discussion.

"In some communities more advanced instruction or a greater amount of reading may be wanted. Write us, and we shall try to help you by suggesting topics and books."

The first Reading-Lesson of this new series comprises 8 pages and 12 topics, and is headed "The Soil: what it is." The second Lesson is on "Tillage and Under-drainage: reasons why."

We consider that the Reading-Course is yet in its experimental stage; but it is promising. As an experiment we are employing public-spirited farmers in three parts of the State to organize Reading-Centers within a small radius of their homes.

If this attempt is successful, we shall hope to extend the enterprise another year if the Extension work is continued.

It will be seen that the central idea of this Reading-Course movement is to educate the farmer rather than to give him mere information. We expect that it will be taken up most efficiently by the younger men. The direct result of it is to awaken a desire for more wisdom and to induce the party to go to school or college. Therefore, it appeals to the rising generation rather more than to the satisfaction of present-day problems.

Remarks by the Director;

The Director desires to say that the efficiency of the work has been greatly promoted by the helpful co-operation of the Secretary of Agriculture, Honorable James Wilson, Director A. C. True and Professor H. W. Wiley, of Washington, D. C. No less helpful have been the hearty support of the Commissioner of Agriculture, Honorable Charles A. Wieting, and the Superintendent of Education, Honorable Charles R. Skinner, and their associates. But most of all do we desire to acknowledge thanks to the many citizens of the State who have so appreciatingly received the instruction and to those who have so heartily entered into the work of investigation.

The various members of the staff seem to be imbued with the true missionary spirit, and have thrown themselves into the work with enthusiasm. Some of the professors and others have given freely of time and advice, writing leaflets and bulletins and working month after month, or even year after year, without remuneration, anxious only that the work be extended and energized.

In conclusion, it may be said that the Nixon fund is not an appropriation to Cornell University, but to the agricultural interests of the State, to be administered by Cornell University. The University has not asked for the legislation. The movement originated with the people and has been maintained by them. The law provides that the money is "to be expended in giving

instruction throughout the State by means of schools, lectures and other university extension methods, or otherwise, and in conducting investigations and experiments; in discovering the diseases of plants and remedies; in ascertaining the best method of fertilization of fields, gardens and plantations; and best modes of tillage and farm management and improvement of live stock; and in printing leaflets and disseminating agricultural knowledge by means of lectures or otherwise; and in preparing and printing for free distribution the results of such investigations and experiments; and for republishing such bulletins as may be useful in the furtherance of the work; and such other information as may be deemed desirable and profitable in promoting the agricultural interests of the State. Such college of agriculture may, with the consent and approval of the commissioner of agriculture, employ teachers and experts and necessary clerical help to assist in carrying out the purposes of this bill."

Every capable judge is pronounced in his conviction that the many agencies—as institutes, bulletins, rural press, experiments, etc.—which have been prosecuted in the farmer's interest during recent years, and in many States, have had a wonderful effect in educating the farmer and in improving agriculture.

I. P. ROBERTS,
Director.

The Following Bulletins are Available for Distribution to Those Who may Desire Them.

39 Creaming and Aerating Milk, 20 pp.
40 Removing Tassels from Corn, 9 pp.
41 Steam and Hot-Water for Heating Greenhouses, 26 pp.
49 Sundry Investigations of 1892, 56 pp.
53 Œdema of the Tomato, 34 pp.
55 Greenhouse Notes, 31 pp.
61 Sundry Investigations of the Year 1893, 54 pp.
64 On Certain Grass-Eating Insects, 58 pp.
69 Hints on the Planting of Orchards, 16 pp.
71 Apricot Growing in Western New York, 26 pp.
72 The Cultivation of Orchards, 22 pp.
73 Leaf Curl and Plum Pockets, 40 pp.
74 Impressions of the Peach Industry in N. Y., 28 pp.
75 Peach Yellows, 20 pp.
76 Some Grape Troubles in Western N. Y., 116 pp
77 The Grafting of Grapes, 22 pp.
78 The Cabbage Root Maggot, 99 pp.
79 Varieties of Strawberry Leaf Blight, 26 pp.
80 The Quince in Western N. Y., 27 pp.
82 Experiments with Tuberculin, 20 pp.
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87 Dwarf Lima Beans, 24 pp.
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93 Cigar-Case-Bearer, 20 pp.
95 Winter Muskmelons, 20 pp.
96 Forcing House Miscellanies, 43 pp.
97 Entomogenous Fungi, 42 pp.
101 The Spraying of Trees and the Canker Worm, 24 pp.
102 General Observations in Care of Fruit Trees, 26 pp.
103 Soil Depletion in Respect to Careo Fruit Trees, 21 pp.
104 Climbing Cutworms in Western, N. Y. 51 pp
105 Test of Cream Separators, 18 pp.
106 Revised Opinions of the Japanese Plums, 30 pp.
109 Geological History of the Chautauqua Grape Belt, 36 pp.
110 Extension Work in Horticulture, 42 pp.
114 Spraying Calendar.
116 Dwarf Apples, 31 pp.
117 Fruit Brevities, 50 pp.
119 Texture of the Soil, 8 pp.
120 Moisture of the Soil and Its Conservation, 24 pp.
122 Second Report upon Extension Work in Horticulture, 36 pp.
123 Green Fruit Worms, 17 pp.
124 The Pistol-Case-Bearer in Western New York., 18 pp.
125 A Disease of Currant Canes, 20 pp.
126 The Currant-Stem Girdler and the Raspberry-Cane Maggot, 22 pp.
127 A Second Account of Sweet Peas, 35 pp.
128 A Talk about Dahlias, 40 pp.
129 How to Conduct Field Experiments with Fertilizers, 11 pp.
130 Potato Culture, 15 pp.
131 Notes upon Plums for Western New York, 31 pp.
132 Notes upon Celery, 34 pp.
133 The Army-Worm in New York, 28 pp.
134 Strawberries under Glass, 10 pp.
135 Forage Crops, 28 pp
136 Chrysanthemums, 24 pp.
137 Agricultural Extension Work, sketch of its Origin and Progress, 11 pp.
138 Studies and Illustrations of Mushrooms; I, 32 pp.
139 Third Report upon Japanese Plums.
140 Second Report on Potato Culture, 24 pp
141 Powdered Soap as a Cause of Death Among Swill-Fed Hogs.
142 The Codling-Moth.
143 Sugar Beet Investigations, 88 pp.
144 Suggestions on Spraying and on the San Josè Scale.
145 Some Important Pear Diseases.
146 Fourth Report of Progress on Extension Work, 26 pp.
147 Fourth Report upon Chrysanthemums, 36 pp.
148 Quince Curculio, 26 pp.
149 Some Spraying Mixtures.

Bulletins Issued Since the Close of the Fiscal Year, June 30, 1898.

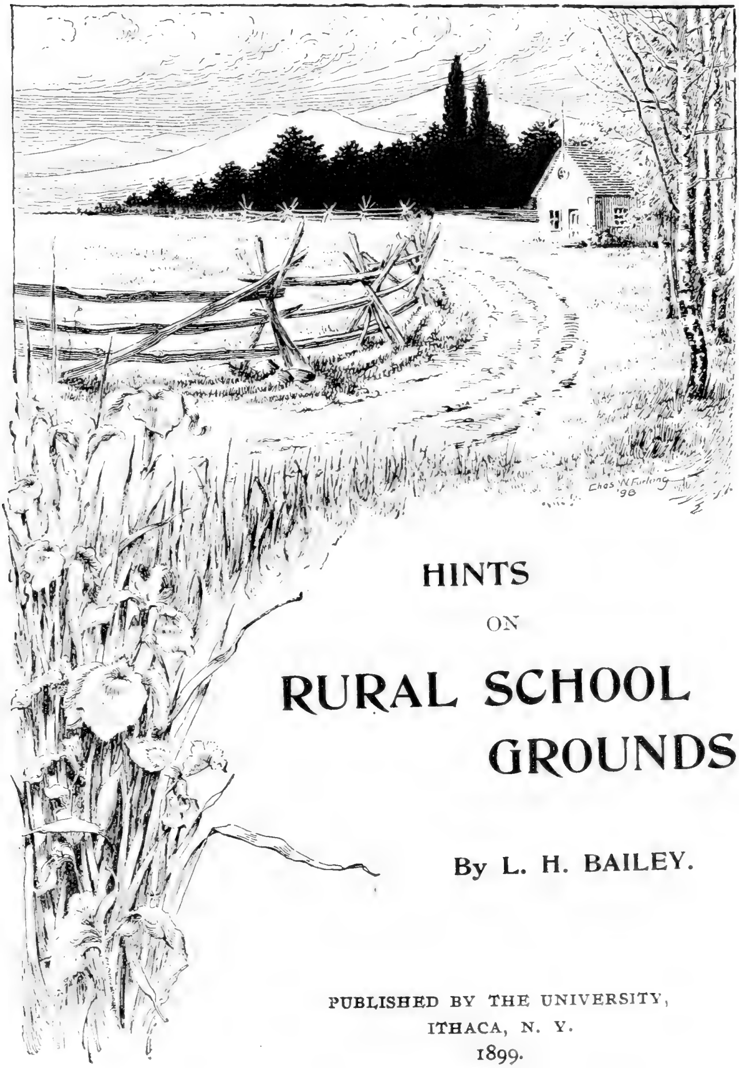
150. Tuberculosis in Cattle and its Control.
151. Gravity or Dilution Separators.
152. Studies in Milk Secretion.
153. Impressions of our Fruit-Growing Industries.
154. Tables for Computing Rations for Farm Animals.
155. Second Report on the San José Scale.
156. Third Report on Potato Culture.
157. The Grape-vine Flea-beetle.
158. Source of Gas and Taint Producing Bacteria in Cheese Curd.
159. An Effort to Help the Farmer.

Bulletin 160. January, 1899.

Cornell University Agricultural Experiment Station.

ITHACA, N. Y.

HORTICULTURAL DIVISION.



HINTS ON RURAL SCHOOL GROUNDS.

By L. H. BAILEY.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1899.

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CORNELL UNIVERSITY, January 2, 1899.

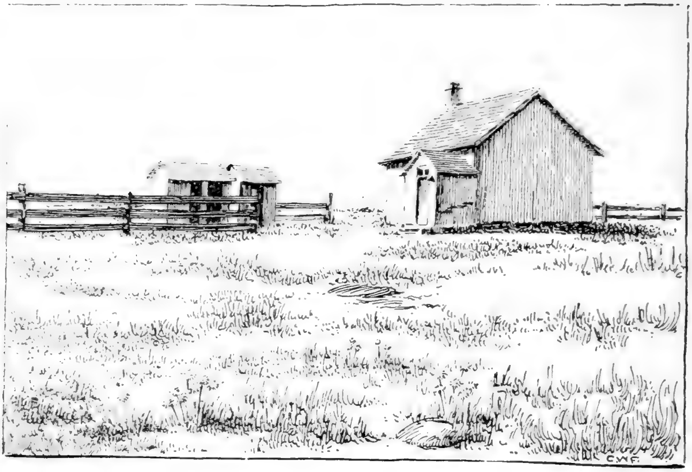
HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

Sir: In the effort to extend the teaching of nature and to popularize farming subjects, we have found the nature-study leaflets to be invaluable. These leaflets are now so well established in the estimation of New York teachers that we are obliged to print them in editions of 25,000. These afford subject-matter for direct teaching. But the surroundings of the child should also be such as to interest him in rural subjects. The home and the school premises should supplement the explicit work of the teacher.

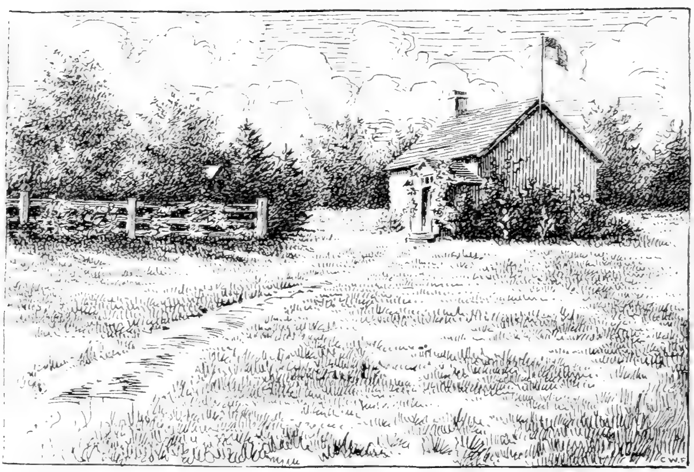
We have endeavored to provide suggestions for the improvement of home surroundings in a number of bulletins; and we hope that more will follow. For many years, Professor Bailey has been studying the problem of the improvement of rural school grounds, but it is only now that he has felt that the time is ripe for a distinct movement in this direction. This bulletin is the first move. It strikes at one of the greatest evils connected with the education of the farmer's children. We hope to follow up the movement, and eventually to give suggestions for the interior of the schoolhouse.

These recommendations are the result of long study of trees and shrubs as adapted to New York State, and of the principles of landscape gardening. The report is submitted for publication as a bulletin under Chapter 67 of the Laws of 1898.

I. P. ROBERTS, Director.



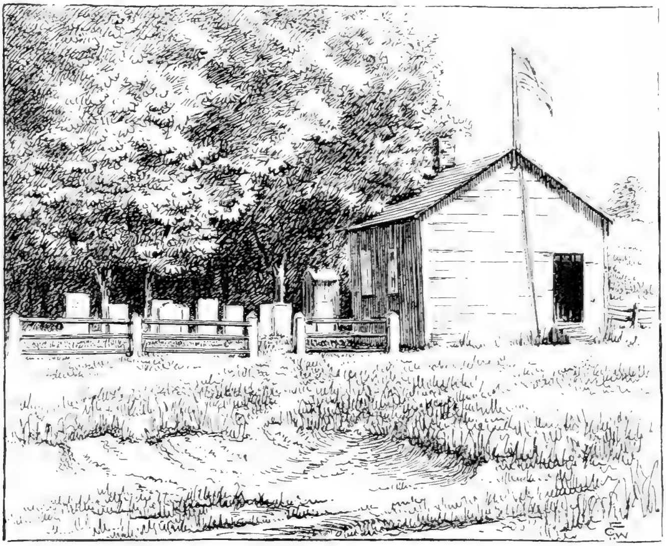
21.—*Where children are taught. An actual example, in one of the most prosperous fruit-growing sections of New York.*



22.—*A suggestion in planting.*

HINTS ON RURAL SCHOOL GROUNDS.

One's training for the work of life is begun in the home and fostered in the school. This training is the result of a direct and conscious effort on the part of the parent and teacher, combined with the indirect result of the surroundings in which the child is placed. The surroundings are more potent than we think; and they are usually neglected. It is probable that the antipathy to



23.—*The beginning and the end,—schoolhouse and graveyard. In eastern New York.*

farm life is formed before the child is able to reason on the subject. An attractive play-ground will do more than a profitable wheat crop to keep the child on the farm.

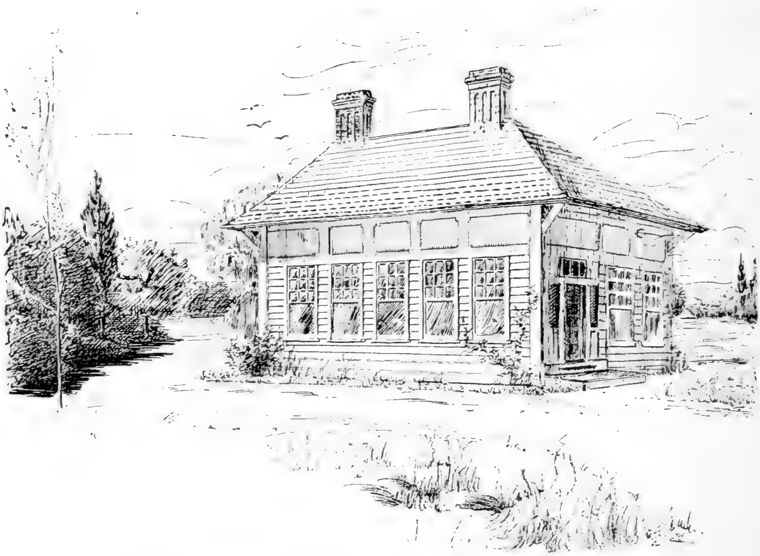
a. THE FACT.

Bare, harsh, cheerless, immodest,—these are the facts about the average rural school ground. Observe Fig. 21.

Children cannot be forced to like the school. They like it only

when it is worth liking. And when they like it, they learn. The fanciest school apparatus will not atone for a charmless school ground. A child should not be blamed for playing truant if he is sent to school in a graveyard. Observe Fig. 23.

It would seem that land is very precious. Very little of it can be afforded for a school ground. A quarter of an acre of good land will raise four bushels of wheat, and this wheat may be worth three or four dollars a year. We cannot afford to de-



24.—*A suggestion for a simple little schoolhouse.*

vote such valuable property to children. We can find a bit of swamp, or a sand hill, or a treeless waste. The first district school I taught was on a heartless hillside. The premises had two or three disconsolate oaks, and an old barrel was stuck in the top of one of them. The second school was on an island in a swamp. The mosquitoes loved it.

The school building is generally little more than a large box. It has not even the charm of proper proportions. A different shape, with the same cost, might have made an attractive building. Even a little attention to design might make a great

difference in the looks of a schoolhouse; and the mere looks of a schoolhouse has a wonderful influence on the child. The railroad corporation likes to build good-looking station-houses, although they have no greater capacity than homely ones. I asked an architect for a simple plan of a cheap school house. He gave me Fig. 24. Plans for the improvement of shoolhouses may be obtained of the Superintendent of Public Instruction, Albany.

The following sentences are extracted from the "Report of the Committee of Twelve on Rural Schools," of the National Educational Association (1897):

"The rural schoolhouse, generally speaking, in its character and surroundings is depressing and degrading. There is nothing about it calculated to cultivate a taste for the beautiful in art or nature."

"If children are daily surrounded by those influences that elevate them, that make them clean and well-ordered, that make them love flowers, and pictures, and proper decorations, they at last reach that degree of culture where nothing else will please them. When they grow up and have homes of their own, they must have them clean, neat, bright with pictures, and fringed with shade trees and flowers, for they have been brought up to be happy in no other environment."

"The rural schoolhouse should be built in accordance with the laws of sanitation and modern civilization. It never will be until the State, speaking through the Supervisor, compels it as a prerequisite for receiving a share of the public funds."

b. HOW TO BEGIN A REFORM.

We will assume that there is one person in each rural school district who desires to renovate and improve the school premises. There may be two. If this person is the school commissioner or the teacher, so much the better.

Let this person call a meeting of the patrons at the schoolhouse. Lay before the people the necessity of improving the premises. Quote the opinions of intelligent persons respecting the degrading influence of wretched surroundings; or even read extracts from this bulletin. The coöperation of the most

influential men of the district should be secured before the meeting is called.

Propose a "bee" for improving the school grounds. John Smith will agree to repair the fence (or take it away, if it is not needed). Jones will plow and harrow the ground, if plowing is necessary. Brown will sow the grass seed. Black and Green and White will go about the neighborhood with their teams for trees and bushes. Some of these may be got in the edges of the woods, but many of the bushes can be picked up in front yards. Others will donate their labor towards grading, planting, and cleaning up the place.

The whole thing can be done in one day. Perhaps Arbor Day can be chosen.

C. THE PLAN OF THE PLACE.

This is the most important part of the entire undertaking,—the right kind of a plan for the improvement of the grounds. The person who calls the meeting should have a definite plan in mind; and this plan may be discussed and adopted. The remainder of this bulletin is devoted to plans for school grounds and means of working them out. If any person is interested in this subject, he should have our Bulletin 121, on the "Planting of Shrubbery."

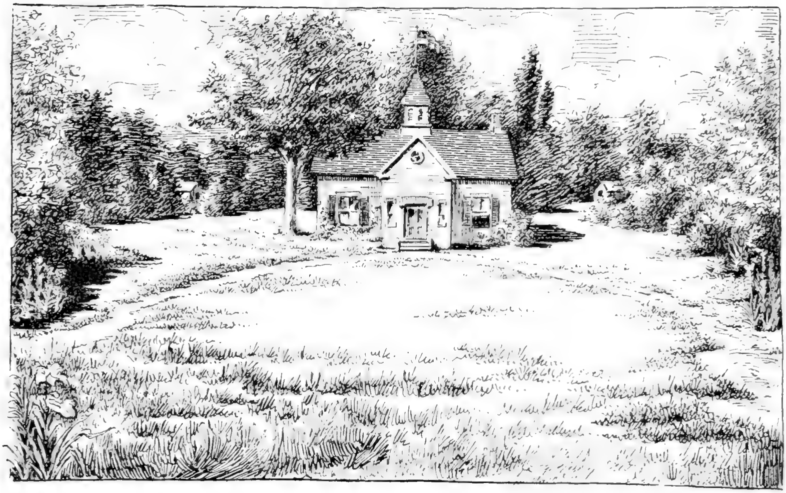
Begin with the fundamentals, not with the details.—If an artist is to make a portrait, he first draws a few bold strokes, representing the general outline. He "blocks out" the picture. With the general plan well in mind, he gradually works in the incidentals and the details,—the nose, eyes, beard.

Most persons reverse this natural order when they plant their grounds. They first ask about the kinds of roses, the soil for snowballs, how far apart hollyhocks shall be planted. It is as if the artist first asked about the color of the eyes and the fashion of the neck-tie; or as if the architect first chose the color of paint and then planned his building. The result of this type of planting is that there is no plan, and the yard means nothing when it is done. Begin with the plan, not with the plants.

The place should mean something.—The home ground should be home-like, retired and cosy. The school ground should be set off from the bare fields and should be open enough

to allow of play-grounds. It should be hollow,—well planted on the sides, open in the interior. The side next the highway should contain little planting. The place should be a picture, not a mere collection of trees and bushes. Fig. 25 shows what I mean.

As seen in the picture (Fig. 25), this style of planting seems to be too elaborate and expensive for any ordinary place. But if the reader will bear with me, he shall learn otherwise.

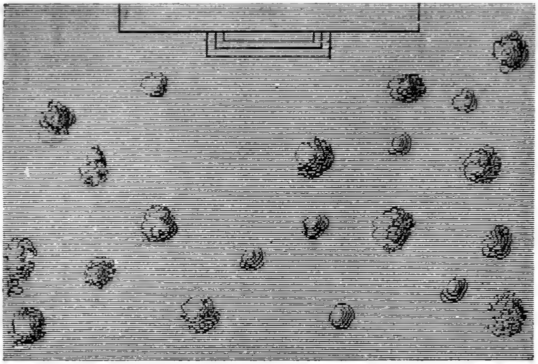


25.—*A picture, of which a schoolhouse is the central figure.*

Keep the center of the place open.— Do not scatter the trees over the place. They will be in the way. The boys will break them down. Moreover, they do not look well when scattered over the whole area. When an artist makes a picture with many people in it, he does not place the persons one by one all over his canvas. He masses them. Thereby he secures a stronger effect. He focusses attention, rather than distributes it.

The diagrams (Figs. 26, 27), taken from Bulletin 121, make this conception plain. The same trees and shrubs can be used to make either a nursery or a picture. But it is more difficult to make the nursery, and to keep it in order, because the trees grow one at a place in the sod, and they are exposed to accidents.

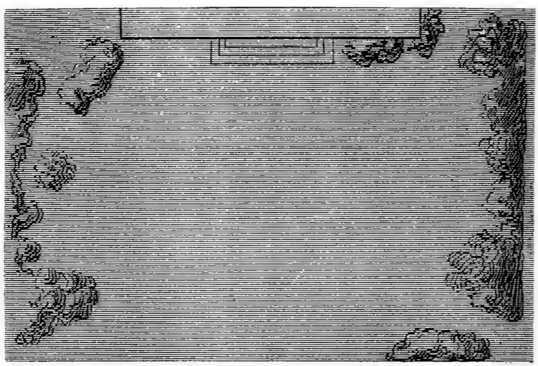
Go to the blackboard. With four lines, represent the borders of the school grounds, as in Fig. 28. Indicate the schoolhouse and the out-buildings. Existing trees may be located by small circles. Now you have the facts, or the fixed points.



26.—*The common or nursery type of planting.*

Now put in the walks. The first fixed point is the front door. The other fixed point is the place or places at which the children enter the grounds. Join these points by the most direct and simplest curves possible. That is all there is of it. In many, or perhaps most places, the house is so near the highway that only a straight walk is possible or advisable.

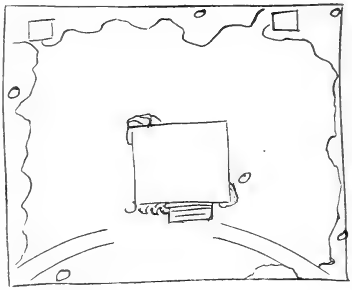
Next comes the planting. Let it be irregular and natural, and represent it by a wavy line, as in Fig. 28. First of all, cover up the out-houses. Then plant heavily on the side next the swamp or a disagreeable barnyard, or in the direction of the prevailing wind. Leave openings in your plan wherever there are views to be had of fine old trees, attractive farm homes, a brook, or



27.—*The proper or pictorial type of planting.*

a beautiful hill or field. Throw a handful of shrubs into the corners by the steps, and about the bare corners of the building.

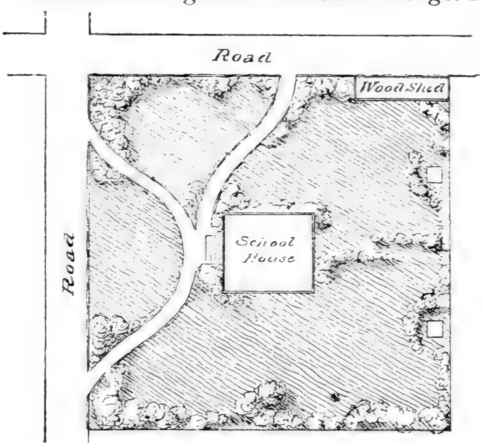
You now have a plan to work to. It has been the work of five minutes at the blackboard.



28.—*The blackboard plan.*

Sometimes the problem is not so simple as all this. There may be three entrances to the grounds and a highway on two sides. Fig. 29 is a plan made for such a place in western New York. It was thought to be necessary to separate the play-grounds of the boys and girls. This was done by a wide hedge-row of bushes running back from the schoolhouse.

An interesting case as shown in Figs. 21 and 22. It is indecent to put the two outbuildings together. But it was assumed that it would not be allowable to move them. The place is bald and cheerless. The outlay of a day's work, and no money, might cause it to look like Fig. 22 inside of three or four years.



29.—*Suggestions for the planting of a school-yard upon four corners. From "Lessons with Plants."*

Perhaps some persons object to so much shrubbery. They look upon it as mere brush. Very well; then use trees alone. But do not scatter them hit and miss over the place. Throw them in at the side, as in Fig. 30. Give room for the children to play; and make the place a picture at the same time. Three or four trees may be planted near the building to shade it, but the heaviest planting should be on the sides.

The mere planting of trees and shrubs is the smaller part of the problem.—Arbor day has emphasized the mere planting of trees. Fortunately, many of the trees do not live. They are too often put in the wrong places. If the love of trees could be combined with some purpose in the planting, the results would be much better. Fig. 31 suggests Arbor Day planting; and this is certainly much better than nothing. These four trees will be useful in their present positions, but the place will still remain bare. The great thing—the border planting—has been omitted, and the incidental thing has been done.

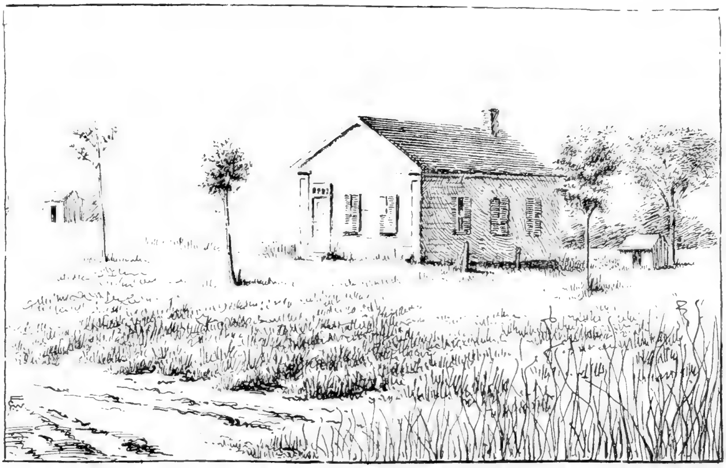
30.—*A border planting of trees.*

Observe how the long foliage-mass adds charm to Fig. 32. A row is better than mere scattered trees. But even this planting is not ideal. Heavy planting should have been made along the fence beyond the schoolhouse. There are too many trees between the border row and the house, although this is not a serious fault. A few bushes and vines would relieve the barrenness of the house; so would one or two trees close against the house on the side next the road. But this place is so much more attractive than most rural school premises that one ought not to find fault with it.

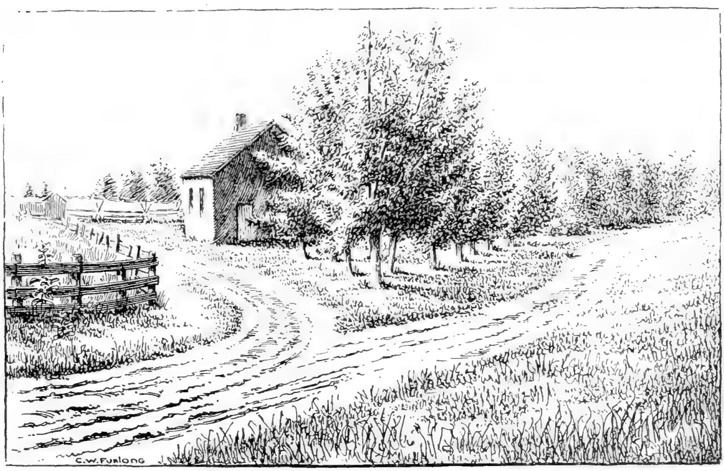
d. HOW TO MAKE THE IMPROVEMENTS.

Every effort should be exerted to do the work well in the beginning. If all preparations are thoroughly considered, and the details carried out with care, the premises should become more attractive year by year with almost no annual outlay of labor. The school grounds should be able to take care of themselves when once the place is set in order. Of course, better results

are to be expected when much labor is put on the grounds each year, but it is useless to advise such expenditure for the rural



31.—*Trees enough in the center, but the place needs a back-ground.*



32.—*A row of willows makes the place attractive.*

schools. But it is surprising what excellent results can be secured with almost no attention from year to year. The beau-

tiful garden in Fig. 34 has received practically no labor for three years except that required to mow the grass.

Making the sod.—In many cases the school yard is already level or well graded and has a good sod, and it is not necessary to plow it and re-seed it. It should be said that the sod on old lawns can be renewed without plowing it up. In the bare or thin places, scratch up the ground with an iron-toothed rake, apply a little fertilizer, and sow more seed. Weedy lawns are those in which the sod is poor. It may be necessary to pull out the weeds; but after they are out, the land should be quickly covered with sod or they will come in again. Annual weeds, as pigweeds, ragweed, can usually be crowded out by merely securing a heavier sod. A little clover seed will often be a good addition, for it supplies nitrogen and has an excellent mechanical effect on the soil.

The ideal time to prepare the land is in the fall, before the heavy rains come. Then sow in the fall, and again in early spring on a late snow. However, the work may be done in spring, but the danger is that it will be put off so long that the young grass will not become established before the dry hot weather comes.

The only outlay of money required for the entire improvement is for grass seed. The best lawn grass for New York is June-grass or blue-grass. Seedsmen know it as Poa pratensis. It weighs but 14 pounds to the bushel. Not less than three bushels should be sown to the acre. We want many very small stems of grass, not a few large ones; for we are making a lawn, not a meadow.

Do not sow grain with the grass seed. The June-grass grows slowly at first, however, and therefore it is a good plan to sow timothy with it, at the rate of two or three quarts to the acre. The timothy comes up quickly and makes a green; and the June-grass will crowd it out in a year or two. If the land is hard and inclined to be too dry, some kind of clover will greatly assist the June-grass. Red clover is too large and coarse for the lawn. Crimson clover is excellent, for it is an annual, and it does not become unsightly in the lawn. White clover is perhaps best, since it not only helps the grass but looks well in the sod. One or two pounds of seed is generally sufficient for an acre.

At first the weeds will come up. Do not pull them. Mow the lawn as soon as there is any growth large enough to mow. Of course, the lawn mower is best, but there is no use of recommending it for rural school yards. Then use the ordinary field mower. When the sod is established, mowing the yard three or four times a year will be sufficient. And here is another advantage of the open-centered yard which I have recommended, — it is easily mown. It would be a fussy matter to mow a yard planted after the fashion of Fig. 26; but one like Fig. 27, is easily managed. A yard like Fig. 25 can be mown in a half hour.

How to make the border planting.—The borders should be planted thick. Plow up the strip. Never plant these trees and bushes in holes cut in the sod. Scatter the bushes and trees promiscuously in the narrow border. In home grounds, it is easy to run through these borders occasionally with a cultivator, for the first year or two.

Make the edges of this border irregular. Plant the lowest bushes on the inner edge. Fig. 33 shows how a certain yard was marked out for the planting. The whole area had been plowed, rolled, harrowed and raked. Grass seed had been sown and raked in. Then a line was drawn, by means of a rake handle, to represent the edges of the border planting. The interior or lawn space was now rolled, and the soft area along the borders was left for the planting. Five years later, the place looked as shown in Fig. 34. Imagine a schoolhouse at the end of that garden!

For all such things as lilacs, mock-oranges, Japan quinces, and bushes that are found along the roadsides, two or three feet apart is about right. Some will die anyway. Cut them back one-half when they are planted. They will look thin and stiff for two or three years; but after that they will crowd the spaces full, lop over on the sod, and make a billow of green. Prepare the land well, plant carefully; andlet the bushes alone.

The kinds of plants for the main planting.—We now come to the details,—the particular kinds of plants to use. One great principle will simplify the matter: the main planting should be for foliage effects. That is, think first of giving the place a heavy bordermass. Flowers are mere decorations.

Select those trees and shrubs which are the commonest, because

they are cheapest, hardiest and most likely to grow. There is no district so poor and bare that enough plants cannot be secured, without money, for the school yard. You will find them in the woods, in old yards, along the fences. It is little matter if no one knows their names. What is handsomer than a tangled fence-row ?

Scatter in a few trees along the fence and about the buildings.

33.—*A newly made landscape garden, ready for the border planting.*

Maples, basswood, elms, ashes, buttonwood, pepperidge, oaks, beeches, birches, hickories, poplars, a few trees of pine or spruce or hemlock,—any of these are excellent. If the country is bleak, a rather heavy planting of evergreens about the border, in the place of so much shrubbery, is excellent.

For shrubs, use the common things to be found in the woods and swales, together with roots which can be had in every old yard. Willows, osiers, witch hazel, dogwood, wild roses, thorn apples, haws, elders, sumac, wild honeysuckles,—these and others can be found in every school district. From the farm yards can be secured snowballs, spireas, lilacs, forsythias, mock-

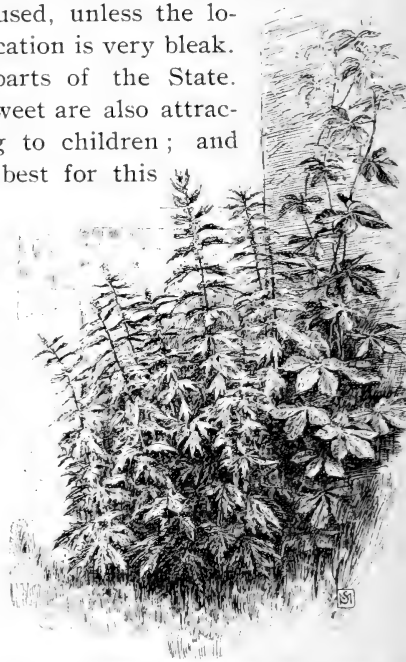
34.—*Five years' growth upon the area shown in Fig. 33. On the Cornell horticultural grounds. From our Bulletin 121.*

35.—*It is easy to make a yard as good as this.*

oranges, roses, snowberries, barberries, flowering currants, honeysuckles and the like.

Vines can be used to excellent purpose on the outbuildings or on the schoolhouse itself. The common wild Virginia creeper (shown on the right in Fig. 36) is the most serviceable. On brick or stone school houses the Boston ivy or Japanese ampelopsis may be used, unless the location is very bleak. This is not hardy in the northern parts of the State. Honeysuckles, clematis and bitter-sweet are also attractive. Bowers are always interesting to children; and actinidia (to be had at nurseries) is best for this purpose.

Kinds of plants for decoration.—Against these heavy borders and in the angles about the building, many kinds of flowering plants can be grown. The flowers are much more easily cared for in such positions than they are in the middle of the lawn, and they also show off better. Notice how striking the holyhocks are in Figs. 34 and 37. They have a background. Even a clump of weeds looks well when it is in the right place. Observe Fig. 36.

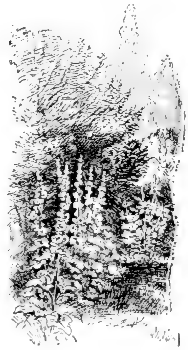


36.—*A clump of weeds in the corner by the house—motherwort and Virginia creeper. How pretty they are!*

It is impossible to grow many flowers in the school ground under present conditions, for what is everybody's business is nobody's business; and then, the place is neglected all through

the summer. But the children can be taught to plant many things.

Only those flowers should be used which are very easy to grow and which have the habit of taking care of themselves. They should also be such as bloom in spring or fall, when the school is in session. Perennial plants—those which live from year to year—are excellent. Of these, day lilies, bleeding hearts, pinks, bluebells, hollyhocks, perennial phlox and hibiscus, are always useful. Nothing is better than the common wild asters and goldenrods. They will grow almost anywhere and they improve when grown in rich ground and given plenty of room ; and they bloom in the fall.



37.—*A dainty bit,—flowers against a background.*

Many kinds of bulbs are useful, especially as so many of them bloom very early in spring. We propose to issue a nature-study leaflet on this subject the coming season. Think of a school yard with crocuses, daffodills and tulips in it !

Annual flowers may be grown along the borders, out of the way of the play-grounds. China asters, petunias and California poppies are very attractive, and they are easy to grow. They bloom in the fall. Phlox, sweet peas, allyssum, and many others are also useful. Consult Bulletin 161.

While the main planting should be made up of common trees and shrubs, a rare or strange plant may be introduced now and then from the nurseries, if there is any money with which to buy such things. Plant it at some conspicuous point just in front of the border, where it will show off well, be out of the way, and have some relation to the rest of the planting. Two or three purple-leaved or variegated-leaved bushes will add much spirit and verve to the place ; but many of them make the place look fussy and overdone.

e. GENERAL REMARKS.

More than one-third of all public schools will probably always be in the country. They will have most intimate relations with rural life. We must make that life attractive to the pupils.

In Europe there are school gardens, and similar plans are

recommended for this country. It is certainly desirable that some area be set aside for the actual cultivation of plants by the children and for the growing of specimens to be used in the school room. However, the conditions of Europe are very different from ours. In the rural school in Germany and other countries, the school house is the teacher's home. He lives in it, or by it. The summer vacation is short. In this country, there is no one to care for the rural school ground in the long summer vacation. Teachers change frequently. It is impossible to have uniformity and continuity of purpose. In the Old World, the rural schools are in the hamlets.

We shall be very glad to correspond with any persons who are interested in improving school premises, either on the lines herein suggested, or in other directions. The improvement must come, or, one by one, the rural schools will die out for lack of pupils. In the struggle for existence, the pupils will more and more seek the more attractive schools. There must be rural schools, whether in the open country or in the hamlet; and wherever they are, they must be cheered and brightened.

A Flower Day every October would be a fitting complement of Arbor Day. Already, flower shows have been held in various rural schools. They are symbols of the harvest. We want to focalize this movement in the coming year. We call upon every citizen for sympathy and coöperation.

A revolution in rural school grounds will not come suddenly. Here and there a beginning will be made; and slowly the great work will spread.

L. H. BAILEY.

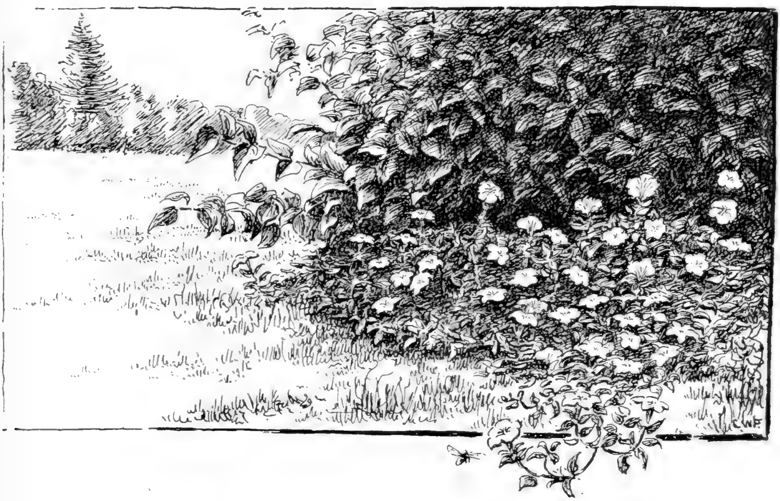
Bulletin 161. **January, 1899.**

Cornell University Agricultural Experiment Station,

ITHACA, N. Y.

HORTICULTURAL DIVISION.

ANNUAL FLOWERS.



By G. N. LAUMAN and L. H. BAILEY.

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CORNELL UNIVERSITY, ITHACA, Jan. 6, 1899.

THE HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

Sir:—The following report is submitted as a bulletin under Chapter 67 of the Laws of 1898. The first part of it is designed for general reading and application, and is a part of Professor Bailey's general movement towards improving rural homes and schools. The second part is more technical, and is designed more for the use of florists and those who make a special study of flower-growing; although the table and summary will enable persons unacquainted with flowers to select kinds for particular colors, heights, seasons, and uses. It is customary to describe flowers in superlative terms, and it is difficult for the beginner to make a wise selection. Only those kinds are included in the table which are easy for the amateur to grow in this State; and it is hoped that the list will spread information of simple flower-growing. This part II. is the work of G. N. Lauman, Assistant in the Horticultural Department, although all the work has been done under the personal direction and care of the head of that Department. Botanical specimens of all these 459 kinds (and of others not reported here) are preserved in the herbarium of the Experiment Station.

I. P. ROBERTS,
Director.

38.—*A cozy back yard. Flowers may be thrown in freely along the borders, not in beds in the center of the area.*

ANNUAL FLOWERS.

I. GENERAL REMARKS. (*L. H. Bailey.*)

EFFORTS have been made in the past few years, under the auspices of the Agricultural Extension work, to improve the surroundings of rural homes. To this end we have issued reports on flowers and the planting of shrubbery; and the present bulletin is another effort in the same direction.

During the past few years, the best thought of many able men and women has been given to the condition of the farmer and the status of agriculture. Many movements looking to the betterment of rural affairs are now in progress. It is probable that every one of them is productive of permanently good results; and the combined effects must be most beneficent. I believe, however, that the pecuniary side of the agricultural question has been too greatly emphasized in these schemes. It is, of course, incontrovertible that the greatest single problem is that of the earning power of the farm; but it is not nine-tenths of the question, as one might conclude from the current agricultural discussions.

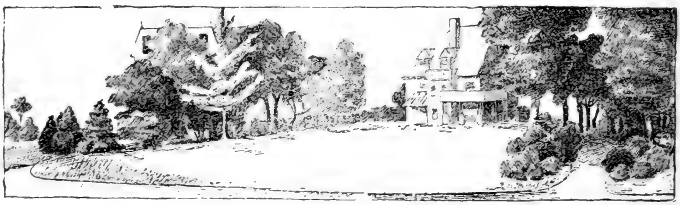
Great numbers of farmers earn enough as it is, but they do not have the knack of doing things with the greatest economy of time and effort, and farm homes are not often designed to afford the greatest pleasure and comfort of living. Every person should know the great fact that the most successful life is the happiest one, and that the happiest one is that in which the common and little things awaken the greatest number of mental impressions. Successful and enjoyable farming, therefore, depends largely upon one's attitude of mind towards the things with which he deals and lives. If one derives pleasure from a daisy, a hill of

potatoes, and a pigweed, then each of these plants is practical and worth the growing.

Like or dislike of the farm is often, and probably generally, formed before the child is old enough to be influenced by the profit-and-loss side of farming. A pleasant and happy home is the very first means of keeping the boy on the farm. One means of making the home attractive is to brighten the place with flowers.

For two years the Horticultural Department has made studies of those flowers which bloom freely the same year the seeds are sown. The primary use of this investigation is to enable us to give advice as to home-making; but it is hoped that the statistics of the plants, as given in Part II., will be useful to florists, catalogue makers, and others who have particular interest in the subject.

Flowers should be accessories.—The main planting of any place should be of trees and shrubs. (Consult Bulletin 121



39.—*The open-centered yard.*

on "Planting of Shrubbery," 160 on "Rural School Grounds," and 90 on "China Asters and Flower Beds.") The flowers are then used as decorations. They may be thrown in freely about the borders of the place, not in beds in the center of the lawn. They show off better when seen against a background: this background may be foliage, a building, a rock, or a fence.

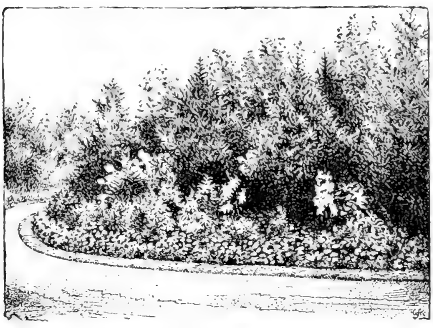
Where to plant flowers is really more important than what to plant. In front of bushes, in the corner by the steps, against the foundation of the residence or outhouse, along a fence or a walk,—these are places for flowers. A single petunia plant against a background of foliage (as shown on the title-

page) is worth a dozen similar plants in the center of the lawn. Fig. 38 shows a cozy back yard in which shrubs and trees are the main features and bright flowers are the incidents. Too many flowers make a place over-gaudy. Too much paint may spoil the effect of a good building. The decoration of a yard, as of a house, should be dainty.


40.—*A dash of color.*

The open-centered yard may be a picture: the promiscuously planted yard may be a nursery or a forest. A little color scattered in here and there puts the finish to the picture. A dash of color gives spirit and character to the brook or pond, to the ledge of rocks, to the old stump, or to the pile of rubbish.

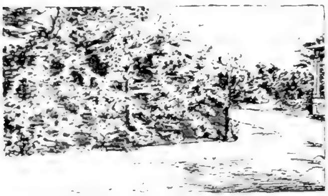
A flower garden.—But the person may want a flower garden. Very well; that is a different matter. It is not primarily a question of decoration of the yard but of growing flowers for flowers' sake. It is not the furnishing of a house, but the collecting of interesting and beautiful furniture. The flower garden, therefore, should be at one side of the residence or at the rear; for it is not allowable to spoil a good lawn even with flowers. The size of the garden and the things to be grown in it must be determined by the likes of the person and the amount of time and land at his disposal; but a good small garden is much more satisfactory than a poor large garden. Prepare the land thoroughly, fertilize it resolve to take care of it, select the kind of plants you like; then go ahead.


41.—*A dainty edging of flowers.*

Plants for screens.—Many annual plants make effective screens, and covers for unsightly places. Wild cucumber (or echinocystis), cobea, and sweet peas may be used to decorate the tennis screen or the chicken-yard fence. The alley fence, the smoke-house, the

children's play-house, may be screened with morning glories, flowering beans, and other twiners and climbers. The windows may be screened and decorated by vines grown either in the ground or in window-boxes.

Efficient screens can be made of many strong-growing and large-leaved plants, of which castor beans, sunflowers, cannas, tobacco and other nicotianas (Fig. 43 is one), striped or Japanese corn, are the chief. But it is not the mission of this bulletin to report upon foliage plants.



42.—The decorated tennis fence.

How to grow annuals.— The annual flowers of the seedsmen are those which give their best bloom in the very year in which the seeds are sown. The true annuals are those plants which complete their entire life-cycle in one season. Some of the so-called annual flowers will continue to bloom the second and third years, but the bloom is so poor and sparse after the first season that it does not pay to keep them.

43.—*Strong-growing and large-leaved herbs make excellent screens.* (*From the French.*)

Most annuals will bloom in central New York if the seeds are sown in the open ground when the weather becomes thoroughly

settled. But there are some kinds, as cosmos and moon-flowers, for which our season is commonly too short to give good bloom. These kinds may be started early in the house or in hotbeds; and similar treatment may be given any plants of which it is desired to secure blooms before the normal time.

Prepare the ground thoroughly and deep. Annuals must make a quick growth. See that the soil contains enough humus or vegetable mold to make it rich and enable it to hold moisture. If the ground is not naturally rich, spade in well-rotted manure or mold from the woods. A little commercial fertilizer may help in starting off the plants quickly. Prepare the land as early in spring as it is in fit condition, and prevent evaporation by keeping the surface loose by means of raking.

If the flowers are to be grown about the edges of the lawn, make sure that the grass roots do not run underneath them and rob them of food and moisture. It is well to run a sharp spade deep into the ground about the edges of the bed every two or three weeks for the purpose of cutting off any grass roots which may have run into the bed. If beds are made in the turf, see that they are three feet or more wide, so that the grass roots will not undermine them. Against the shrub borders, this precaution may not be necessary. In fact, it is desirable that the flowers fill all the space between the overhanging branches and the sod. Observe the picture on the title-page.

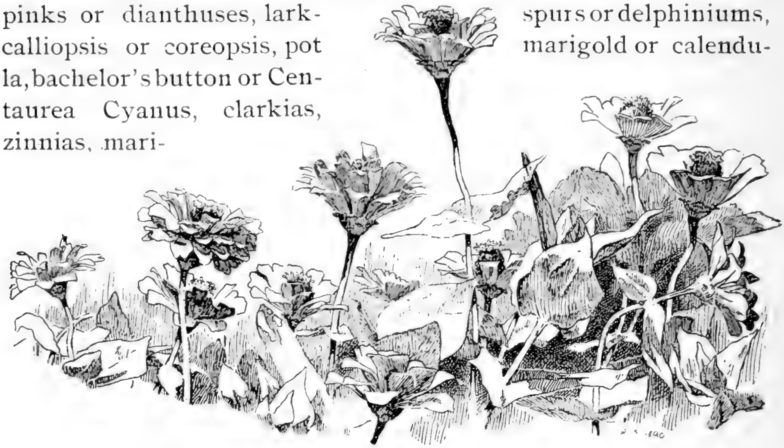
Sow the seeds freely. Many will not germinate. Even if they do all germinate, the combined strength of the rising plantlets will break the crust on the hard soils; and in the thinning which follows, only strong and promising plants are allowed to remain. Better effects are also often secured when the colors are in masses, especially if the flowers are thrown into the bays of heavy shrub borders like those in Fig. 38.

Plants continue to bloom for a longer period if they are not allowed to produce seeds. The flowers should be picked, if possible, as soon as they begin to fade.

The kinds of annuals.—In the selection of the kinds of annuals, one's personal preference must be the guide. Yet there are some groups which may be considered to be standard or general-purpose plants. They are easily grown almost anywhere

and are sure to give satisfaction. The remaining plants are mostly such as have secondary value, or are adapted to particular purposes or uses. By consulting the summary lists in Part II., the reader may be able to select plants to his liking.

The groups which most strongly appeal to the writer as staple or general-purpose types are the following: Petunias, phloxes, pinks or dianthuses, larkspurs or delphiniums, calliopsis or coreopsis, pot marigold or calendula, bachelor's button or Centaurea Cyanus, clarkias, zinnias, mari-



44.—*Zinnias. Often known as "youth and old age."*

golds or tagetes, collinsias, gilias, California poppies or eschscholtzias, verbenas, poppies, China asters, sweet peas, nemophilas, portulaccas, silenes, candytufts or iberis, alyssum, stocks or matthiolas, morning-glories, nasturtiums or tropaeolums.

Annual flowers possess a great advantage over perennials in the fact that they appeal strongly to the desire for experiment. The seeds are sown every year, and there is sufficient element of uncertainty in the results to make the effort interesting; and new combinations can be tried each year.

Do not cut the old stalks down in the fall. They will stand in the snow all through the winter, and remind you of the bursting summer time and the long-ripening fall; and the snow-birds will enjoy them.

A word with the boys and girls.—Let us make a flower garden next summer! We can make it mornings and evenings, and it shall belong to us alone. We shall own it; and we shall see

the rain fall on it and watch the bees and moths collecting the honey from the flowers.

Our garden must be small, for we want a good one. It shall be the best garden in the neighborhood. We shall find a place beside the back fence, or alongside the barn, or in some other out-of-the-way place. It must be in the sunshine, and the eaves must not drip on it.

We shall shake the earth out of the sod and then carry the grass roots away. We shall bring a wheelbarrow load of rich earth from the barn-yard.

I shall make my bed about four feet wide and eight feet long. I do not want it very big, or I shall not have time to go fishing. I do not know what kinds of flowers you want to grow, but I shall plant phlox, petunias, China asters, and, I think, California poppies. By having four kinds, I can have a space two feet wide for each,—that will make a bed four feet by two, of each kind. I wonder which of us will get the most flowers from these beds? Write me in the fall and let me know how many you had.

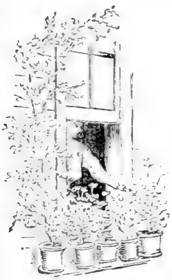
45.—*Winter is coming. The evening primrose in seed.*

Let me tell you how to water the plants. I wonder if you have a watering pot? If you have, put it where you cannot find it, for we are going to water this garden with a rake! We want you to learn, in this little garden, the first great lesson in farming,—how to save the water in the soil. If you learn that much next summer, you will know more than many old farmers do. You know that the soil is moist in the spring when you plant the seeds. Where does this moisture go to? It dries up,—goes off into the air. If we could cover the soil with something, we

46.—*A young gardener.*

should prevent the moisture from drying up. Let us cover it with a layer of loose, dry earth! We shall make this covering by raking the bed every few days,—once every week anyway, and oftener than that if the top of the soil becomes hard and crusty, as it does after a rain. Instead of pouring water on the bed, therefore, we shall keep the moisture in the bed.

If, however, the soil becomes so dry in spite of you that the plants do not thrive, then water the bed. Do not sprinkle it, but water it. Wet it clear through at evening. Then in the morning, when the surface begins to dry, begin the raking again to keep the water from getting away. Sprinkling the plants every day or two is one of the surest ways to spoil them.

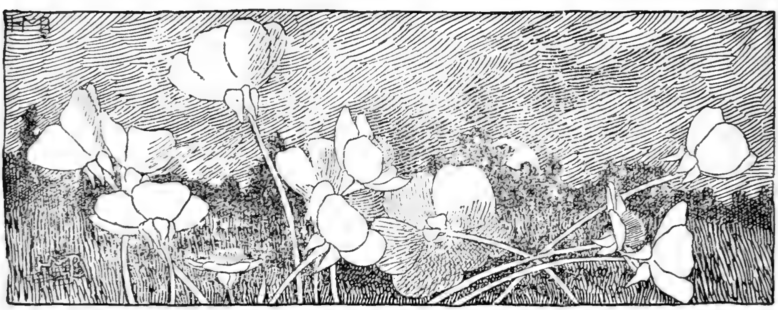


47.—*A window garden.*

Perhaps you live in the city, and have no yard. Then you can grow the plants in pots or boxes in the window or on the roof. But plants in pots and boxes needs lots of water.

48.—*A box garden.*

Why not have a flower show in the school next fall? Ask the teacher about it.



II. STATISTICS OF EASILY-GROWN ANNUALS.

(*G. N. Lauman.*)

In 1897, over four hundred kinds of annual flowers and in 1898 over fifty kinds, not including China asters and sweet peas,* were grown on the grounds of the Horticultural Department of Cornell University. In 1897, most of the seeds were sown May 21, while in 1898 it was June 6 before the seeds were sown. The soil varied somewhat, but it was light and well tilled, and only moderately rich. Both seasons were very wet, and that of 1897 was cold during July and August. The falls of both years were very favorable to continued plant growth, and that of 1898 was spared a frost at the usual time. About 250 other kinds were grown or sown, but they either did not germinate or seemed to be unadapted to general use at this place.

The following table gives the data which were taken from the plants from time to time and summaries are given to facilitate the selection of plants for particular purposes. The names are those in use among seedsmen, and no attempt has been made to revise them to accord with the latest botanical nomenclature.

Annuals are most useful for quick effects, to fill vacant places about shrubbery and in bulb beds. It is generally advisable to sow the seed rather profusely in order to provide against failures, particularly if the ground is dry and not in good tilth. All the annuals here mentioned are very easily grown, and no instructions are needed in this bulletin. If, however, the reader wishes details for their cultivation, the catalogues of the leading seedsmen may be consulted.

This is not the record of a variety test. The effort has been made to give the inquirer, in small compass, those facts about annuals which he chiefly desires to know for practical purposes. Similar information can often be secured from seedsmen's catalogues, and these should always be consulted ; but one does not always know to what latitudes, soils and seasons those remarks

*An account of China asters, with remarks on flower beds, is contained in our Bulletin 90. Sweet peas are considered in Bulletins 111 and 127.

may apply. The statistics given herewith are the actual records of how the plants behaved at Ithaca, under such fair and common conditions as ninety-nine out of every hundred persons are able and willing to give. A very important part of this record is the fact that the results are comparable: that is, all the plants were grown at the same place and most of them in the same year, whereas statistics of this kind are usually compiled from records made in different places and in different years. Our records are all made directly from the plants themselves, with no consultation of other sources of information.

These lists emphasize the riches which are now at the disposal of every home-maker, and which the enterprising seedsmen have brought from the ends of the earth. A dollar's selection is sufficient to brighten the home from June until snow. We believe that all the flowers mentioned in the table are suitable for genera cultivation in this State.

Explanation of table.—The first column gives the names of plants, the second, date of first bloom, the third, date of full bloom, the fourth, date of last bloom. Plants marked with an asterisk (*) were grown in 1898; all others were grown in 1897. Ju. stands for June, Jl., July, A., August, S., September, O., October. A cross (+) means still in bloom after a hard frost.

The fifth column gives average height and habit of plants:

in. = inches.	t. = trailing on ground.
s. = strict or erect.	c. = tendril climbing.
sp. = spreading on ground.	tw.= twiner.

The sixth column gives colors of flowers in the following abbreviations:

r. = red.	b. = blue.	w. = white.
y. = yellow.	o. = orange.	l. = light.
d. = dark.	s. = striped or spotted.	e. = eye.

Body of color is mentioned first: r. y. e. = red with yellow eye. d. r. = dark red.

Of some varieties, several samples, from different packets, were grown, and these appear as duplicates in the list. The abbreviation fl. pl. stands for *flore pleno*, "flowers double."

Names of plants.	First bloom.	Full bloom.	Last bloom.	Height and habit.	Color.	Remarks.
*1 Abronia umbellata	Jl. 28		O. 28+	13 in. s.	b.	
2 Abronia umbellata grandiflora	Jl. 19	A. 3	O. 18+	6 in. t.	b., w. e.	Good under adverse conditions.
3 Acroclinium album	Jl. 8	Jl. 22	A. 23	16 in. s.	w.	
4 Acroclinium roseum	Jl. 8	Jl. 22	A. 26	17 in. s.	l. r.	Everlastings.
5 Acroclinium, double rose	Jl. 8	Jl. 22	A. 26	17 in. s.	l. r.	Flowers often ruined by rains.
6 Acroclinium, double white	Jl. 8	Jl. 22	A. 23	17 in. s.	w.	
7 Adonis aestivalis	A. 11	A. 17	O. 18+	20 in. s.	d. r. b. e.	Foliage good.
8 Adonis autumnalis	A. 11	A. 21	O. 18+	20 in. s.	r. b. e.	
9 Ageratum Mexicanum album	Ju. 21	Ju. 30	O. 18	31 in. s.	w.	
10 Ageratum Mexicanum, blue	Ju. 29	Jl. 28	O. 18	32 in. s.	b.	Profuse and continuous bloomers.
11 Ageratum Mexicanum, dwarf blue	Ju. 28	Jl. 21	O. 18	24 in. s.	b.	
12 Agrostemma Coeli-Rosa	A. 18		A. 30			
13 Amarantus Abyssinicus	A. 12	A. 23	S. 16		d. r.	
14 Amarantus atropurpureus	Jl. 10	Jl. 22				Rather coarse but gives good color
15 Amarantus bicolor ruber	Jl. 28	A. 11		40 in. s.		effects in masses.
16 Amarantus cruentus	Jl. 12	Jl. 28				
17 Amarantus tricolor splendens	Jl. 21					
*18 Alyssum, sweet	Jl. 28	A. 14	O. 28	10 in. sp.	w.	
*19 Alyssum, sweet compacta	A. 14	S. 1	O. 28	7 in. sp.	w.	Good for edging.
20 Argemone grandiflora lutea	Jl. 10	Jl. 24	O. 18+	34 in. s.	y.	
21 Argemone grandiflora	Jl. 10	Jl. 28	O. 18+	34 in. s.	l. y.	Not very profuse bloomer.
*22 Asperula azurea setosa	Jl. 28		S. 21	9 in. s.	w.	Free flowering.
23 Bartonia aurea	Ju. 30	Jl. 22	O. 6	28 in. s.	y.	In exposed position injured by wind.
24 Brachycome iberidifolia	Jl. 20	Jl. 28	O. 18	10 in. s.	b.	Good for edging.
25 Brachycome iberidifolia alba	Jl. 12	Jl. 22	O. 18	13 in. s.	w.	Good for edging.
*26 Browallia Czerwiakowski	A. 16	S. 2	S. 21	13 in. s.	l. b.	
*27 Browallia elata	A. 14	S. 2	S. 21	13 in. s.	b.	
*28 Cacalia	Jl. 22	A. 14	S. 21	14 in. s.	o.	

Names of plants.	First bloom.	Full bloom.	Last bloom.	Height and habit.	Color.	Remarks.
*29 Cacalia scarlet	Jl. 28	A. 16	S. 21	14 in. s.	d. r.	Free flowering, for bedding.
*30 Calandrinia grandiflora	A. 16	S. 3	O. 8	14 in. s.	l. r.	
*31 Calandrinia umbellata elegans	A. 16	S. 1	O. 15	10 in. s.	r.	
32 Calendula officinalis	Jl. 13	Jl. 22	O. 18+	19 in. s.	y.	
33 Calendula officinalis, Meteor	Jl. 13	Jl. 22	O. 18+	20 in. s.	y.	
34 Calendula officinalis, Prince of Orange	Jl. 13	Jl. 22	O. 18+	24 in. s.	o.	Pot marigolds.
35 Calendula officinalis fl. pl	Jl. 13	Jl. 22	O. 18+	26 in. s.	o.	Very profuse bloomers, and of the easiest culture.
36 Calendula pluvialis	Jl. 13	Jl. 20	O. 18+	20 in. s.	w., d. e.	
37 Calendula Pongei	Jl. 20	A. 27	O. 18+	24 in. s.	w.	
38 Calendula sulphurea, fl. pl	Jl. 13	Jl. 22	O. 18+	16 in. s.	y.	
39 Calendula suffruticosa	Jl. 13	Jl. 22	O. 18+	18 in. s.	y.	
40 Calliopsis bicolor marmorata	Jl. 19	Jl. 28	O. 18	22 in. s.	y. br. e.	
41 Calliopsis cardaminifolia	A. 10	A. 17	O. 13	18 in. s.	y. br. e.	Fine for bedding.
42 Calliopsis elegans picta	Jl. 21	Jl. 24	S. 18	24 in. s.	y. br. e.	
*43 Callirrhoe involucrata	Jl. 21	A. 30	O. 28+	7 in. s.	l. r.	For bedding.
*44 Callirrhoe pedata nona	Jl. 28	A. 30	O. 28+	11 in. s.	r.	Bright flowered.
*45 Callirrhoe pedata	Jl. 29	S. 5	O. 28+	21 in. s.	l. r.	
46 Cardiospermum Halicacabm	Jl. 28	A. 3	S. 3	24 in. c.	w.	Not trained to a support.
47 Carduus benedictus	Jl. 28	A. 5	O. 18+	26 in. sp.	y.	Flowers inconspicuous.
48 Centaurea Americana	A. 18	A. 23	S. 15	36 in. s.	d. b.	Curious and attractive buds.
49 Centaurea cyanus. Victoria dwarf compact	Jl. 13	Jl. 21	O. 18+	10 in. s.	b.	
50 Centaurea cyanus minor Blue	Jl. 8	Jl. 28	O. 18+	18 in. s.	b.	Common Bachelor's Buttons. Always desirable.
51 Centaurea Cyanus minor Emperor William	Jl. 7	Jl. 28	O. 18+	24 in. s.	d. b.	
52 Centaurea suaveolens	Jl. 19	A. 3	O. 14	18 in. s.	w.	The "Sweet Sultan." Very showy when in bloom.
53 Centaurea suaveolens	Jl. 13	Jl. 20	A. 17	18 in. s.	y.	

54 Centauridium Drummondii	A. 11	A. 28	O. 18+	36 in. s.	y.	Tree-like in shape. Good.
55 Centranthus macrosiphon	Jl. 21	A. 5	O. 18+	18 in. s.	l. r.	
56 Centranthus macrosiphon albus	A. 3	A. 21	O. 18+	22 in. s.	w.	
57 Centranthus macrosiphon nanus	Jl. 22	A. 11	A. 31	11 in. s.	l. r.	
58 Cerinthe retorta	Jl. 23	Jl. 28	O. 18+	32 in.	y.	Much visited by bees.
59 Cheiranthus Cheiri	Jl. 13	Jl. 20	O. 18+	24 in. s.	d. y.	
60 Chrysanthemum Burridgeanum	Jl. 10	Jl. 21	O. 9	20 in. s.	w., y. e.	
61 Chrysanthemum carinatum eclipse	Jl. 14	Jl. 22	O. 18+	20 in. s.	y.	
62 Chrysanthemum carinatum	Jl. 13	Jl. 28	O. 18	17 in. s.	w., y. e.	
63 Chrysanthemum carinatum	Jl. 13	Jl. 22	O. 18	22 in. s.	y., b. e.	Largest flowers.
64 Chrysanthemum coronarium album	Jl. 13	Jl. 22	O. 18	32 in. s.	w., y. e.	Very minute eye.
65 Chrysanthemum coronarium double yellow	Jl. 13	Jl. 28	O. 18	32 in. s.	y.	All these chrysanthemums are interesting and easy to grow.
66 Chrysanthemum coronarium sulphureum, fl. pl	Jl. 15	Jl. 28	O. 18	26 in. s.	y.	
67 Chrysanthemum tricolor	Jl. 13	Jl. 28	O. 18	25 in. s.	d. r., y. e.	
68 Chrysanthemum tricolor Dunnettii	Jl. 13	Jl. 24	O. 9	22 in. s.	y.	
69 Chrysanthemum tricolor hybridum	Jl. 13	Jl. 22	O. 18	24 in. s.	y., b. e.	
70 Clarkia elegans alba, fl. pl	Jl. 6	Jl. 22	S. 2	36 in. s.	w.	Clarkias are always interesting.
71 Clarkia elegans rosea	Jl. 3	Jl. 22	A. 17	28 in. s.	l. r.	
72 Clarkia elegans rosea, fl. pl.	Jl. 3	Jl. 22	A. 23	30 in. s.	l. r.	
*73 Cleome spinosa	A. 14	A. 20	O. 10	40 in. s.	w.	
74 Collinsia bartsiaefolia	Jl. 6	Jl. 22			d. b.	
75 Collinsia bicolor	Jl. 8	Jl. 22	S. 4	10 in. sp.	d. b., w. s.	Very free flowering.
76 Collinsia bicolor alba	Jl. 6	Jl. 22	S. 13	9 in. sp.	w.	
77 Collinsia candidissima	Jl. 8	Jl. 22	S. 10	9 in. sp.	w.	The collinsias are excellent little herbs.
78 Collinsia multicolor	Jl. 6	Jl. 22			w.	
79 Collinsia multicolor marmorata	Jl. 8	Jl. 22	S. 27	10 in. sp.	b. w.	

Names of plants.	First bloom.	Full bloom.	Full bloom.	Height and habit.	Color.	Remarks.
80 Collomia coccinea	Jl. 22	A. 5	S. 3	13 in.	l. r	
81 Convolvulus major	A. 7	A. 23	S. 15	96 in. tw.	w.	
82 Convolvulus minor	Jl. 8	Jl. 22	O. 18+	15 in. sp.	b.	Dwarf morning glories. All C. minor varieties very profuse bloomers.
83 Convolvulus minor albus	Jl. 10	Jl. 22	O. 18+	12 in. sp.	w.	
84 Convolvulus minor	Jl. 10	Jl. 22	O. 18+	12 in. sp.	d. b.	
85 Convolvulus minor unicaulis	Jl. 14	A. 3	O. 18+	15 in. sp	b., w. y. e.	
86 Convolvulus tricolor roseus	Jl. 10	Jl. 22	O. 18+	12 in. sp.	r., y. e.	
*87 Cosmidium Burridgianum	A. 16	S. 5	O. 28	19 in. s.	y., b. c.	Fine for bedding.
88 Cucumis erinaceus, hedge-hog gourd	Jl. 28	A. 11	S. 1	96 in. c.	w.	Curious fruits which throw their seeds forcibly.
89 Cucumis odoratissimus	Jl. 31	A. 12	S. 8	96 in. c.	y.	Gourds are useful for covering waste places.
Cucurbita– Gourds,						
90 Mianature bottle	Jl. 22	Jl. 28	S. 8	96 in. c.	y.	
91 Dipper	Jl. 28	A. 10		96 in. c.	y.	
92 Mock orange	Jl. 10	Jl. 28	S. 7	96 in. c.	w.	
93 Spoon	Jl. 10	Jl. 28	S. 11	96 in. c.	w.	
*94 Sugar trough	Jl. 21	A. 7	S. 10	96 in. c.	w.	
95 Cyclanthera pedata	A. 22	S. 3	O. 15	36 in. tw.	w.	
96 Datura cornucopia	Jl. 20			30 in. s.	w.	
97 Datura, fastuosa	A. 8	A. 28	O. 18	35 in. s.	w.	Produced triple flowers.
98 Datura, New Golden Queen	S. 7			36 in. s.	y.	Produced triple flowers.
99 Delphinium, double	A. 5	A. 17	S. 7	18 in. s.	w.	
100 Delphinium	A. 3	A. 12	S. 13	20 in. s.	l. r.	
101 Dianthus, double white Margaret	A. 12	S. 15	O. 18+	15 in. s.	w.	The dianthuses or pinks have fine colors and fragrance.
102 Dianthus, half dwarf early Margaret	Jl. 26	A. 27	O. 18+	13 in. s.	l. r.	
103 Dianthus, Dwarf Perpetual	A. 12	S. 18	O. 18+	15 in. s.	r.	
104 Dianthus, double white Margaret	A. 26		O. 18+	15 in. s.	w.	
105 Dianthus, Comtesse de Paris	A. 26		O. 18+	14 in. s.	y.	

106	Dianthus, double violet Margaret	Jl. 31	A. 28	O. 18+	15 in. s.	d. b.	
107	D. caryophyllus semperflorens	A. 26	S. 15	O. 18+	15 in. s.	w.	
108	D. Chinensis, double	Jl. 13	Jl. 22	O. 18+	15 in. s.	w.	
109	D. Chinensis, double	Jl. 19	Jl. 22	O. 18+	15 in. s.	d. r.	
110	D. dentosus hybridus	Jl. 16	Jl. 28	O. 18+	15 in. s.	d. b.	
111	D. Heddewigii, Eastern Queen		Jl. 22	O. 18+	15 in. s.	l. r.	Foliage continues green through winter. Always desirable.
112	D. Heddewigii, Mourning Cloak	Jl. 31	A. 9	O. 18+	15 in. s.	d. r.	
113	D. Heddewigii, Crimson Belle	Jl. 17	Jl. 28	O. 18+	14 in. s.	r.	
114	D. imperialis, fl. pl.	Jl. 17	Jl. 22	O. 18+	15 in. s.	d. r.	
115	D. imperialis, Dwarf, fl. pl.	Jl. 17	Jl. 22	O. 18+	15 in. s.	w.	
116	D. laciniatus, "Salmon Queen"	Jl. 29	A. 9	O. 18+	13 in. s.	s.	
117	D. plumarius	Jl. 19	Jl. 28	O. 18+	14 in. s.	w.	
118	D. superbus, Dwarf, fl. pl.	Jl. 20	Jl. 28	O. 18+	14 in. s.	w.	
119	Picotee	A. 11	A. 28	O. 18+	14 in. s.	y.	
120	Elscholtzia cristata	Jl. 20			15 in. s.	l. b.	
121	Erysimum Arkansanum	Jl. 10	Jl. 22	O. 18+	30 in. s.	y.	
122	Erysimum Peroffskianum	Jl. 10	Jl. 22	O. 18+	26 in. s.	o.	
123	Eschscholtzia Californica	Jl. 10	Jl. 22	O. 18+	16 in. sp.	y., o. c.	
124	Eschscholtzia C., Rose cardinal	Jl. 10	Jl. 22	O. 18+	15 in. sp.	r.	California poppies.
125	Eschscholtzia C., alba	Jl. 10	Jl. 22	O. 18+	16 in. sp.	w.	Fine for bedding. Profuse flowering. Foliage attractive. Blooms after frost. Excellent.
126	Eschscholtzia crocea plena	Jl. 10	Jl. 22	O. 18+	12 in. sp.	o.	
127	Eschscholtzia, Mandarin	Jl. 13	Jl. 22	O. 18+	14 in. sp.	o.	
128	Eschscholtzia maritima	Jl. 10	Jl. 22	O. 18+	14 in. sp.	y.	
129	Eschscholtzia tenuifolia	Jl. 13	Jl. 22	O. 18+	14 in. sp.	y.	
130	Euphorbia marginata	S. 4	S. 9	O. 18	36 in. s.	w.	Foliage conspicuous. Known as "Snow-on-the-Mountain."
131	Eutoca viscida	Jl. 13	Jl. 22	S. 1	24 in. s.	b.	
132	Eutoca Wrangeliana	Jl. 13	Jl. 22	A. 19	22 in. s.	l. b.	
*133	Gaillardia	Jl. 13	A. 19	O. 28+	13 in. s.	r., d. c.	

Names of plants.	First bloom.	Full bloom.	Last bloom.	Height and habit.	Color.	Remarks.
134 Gaillardia picta	Jl. 21	A. 5	O. 18+	14 in. s.	y.	Very showy. Gaillardias should be better known.
*135 Gaillardia picta	A. 16	S. 5	O. 28+	19 in. s.	r., d. c.	
*136 Gaillardia picta Lorenziana	A. 14	S. 5	O. 28+	18 in. s.	y.	
137 Gamolepsis Tagetes	Jl. 13	Jl. 28	S. 13	12 in. s.	y.	
138 Gilia achilleaefolia	Jl. 10	Jl. 16	A. 31	18 in. s.	b.	Very free flowering and attractive. (138–147)
139 Gilia a. alba	Jl. 6	Jl. 21	O. 18+	15 in. s.	w.	
140 Gilia a. rosea	Jl. 6	Jl. 21	A. 30	20 in. s.	l. r.	
141 Gilia capitata	Jl. 6	Jl. 22	O. 18+	30 in. s.	l. b.	
142 Gilia c. alba	Jl. 6	A. 10	O. 18+	31 in. s.	w.	
143 Gilia laciniata	Jl. 13	A. 7	O. 18+	12 in. s.	l. b.	
144 Gilia linifolia	Jl. 14	Jl. 28	A. 27	12 in. s.	w.	
145 Gilia nivalis	Jl. 10	Jl. 22	S. 8	15 in. s.	w.	
146 Gilia tricolor	Jl. 10	Jl. 22	O. 18 +	18 in. s.	l.b. marg.	
147 Gilia tricolor rosea splendens	Jl. 13	Jl. 22	O. 18 +	20 in. s.	l.r. marg.	
148 Godetia, Bijou	Jl. 22	A. 2	O. 18 +	6 in. s.	l. r.	
149 Godetia, Duchess of Albany	Jl. 22	A. 28	O. 18 +	9 in. s.	w.	Very large flowers.
150 Godetia, Fairy Queen	A. 2	A. 11	O. 18 +	10 in. s.	w.	Very liable to root disease; otherwise to be recommended. (150–158)
151 Godetia, Lady Albemarle	Jl. 20	Jl. 28	S. 15	8 in. s.	r.	
152 Godetia, Lady Satin Rose	Jl. 20	Jl. 24	O. 18 +	8 in. s.	r.	
153 Godetia, Prince of Wales	Jl. 22	Jl. 28	O. 18 +	10 in. s.	d. r.	
154 Godetia Whitneyi	Jl. 20	Jl. 28	O. 18 +	11 in. s.	d. r.	
155 Godetia W., Brilliant	Jl. 30	A. 5	S. 11	12 in. s.	d. r.	
156 Godetia W., Duke of Fife	Jl. 31	A. 5	S. 13	11 in. s.	l. r.	
157 Godetia grandiflora maculata	Jl. 20	Jl. 24	O. 18 +	10 in. s.	w., r. s.	
158 Godetia rubicunda splendens	Jl. 21	A. 3		11 in. s.	r.	
159 Gypsophila muralis	Jl. 10	Jl. 22	O. 18 +	6 in.	d. b.	
160 Helianthus, Double green centered	Jl. 28	A. 7	S. 8	48 in. s.	y.,	
161 Helianthus, Globe flowered	A. 12	A. 21	S. 15	52 in. s.	y.,	

162	Helianthus, Dwarf, variegated foliage	A.	7	A.	23	S.	13	46 in. s.	y., br. c.	Sunflowers.
163	Helianthus, Dwarf, Henry Wilde	Jl.	20	Jl.	28	S.	16	72 in. s.	y., br. c.	
164	Helianthus, Single Russian	Jl.	21	Jl.	30	S.	4	84 in. s.	y., br. c.	
165	Helianthus, California dbl.	Jl.	31	A.	11	S.	8	60 in. s.	y., br. c.	Flowers large and numerous. Good for backgrounds. Silvery foliage.
166	Helianthus, Dwarf double	Jl.	28	A.	10	S.	13	40 in. s.	y., br. c.	
167	Helianthus, Primrose-color'd	Jl.	21	A.	12	S.	13	62 in. s.	y., br. c.	
168	Helianthus argophyllus	A.	17	A.	28	S.	16	50 in. s.	y., br. c.	
169	Helianthus cucumerifolius	Jl.	22	A.	28			40 in. s.	y., br. c.	
170	Helianthus macrophyllus giganteus	A.	4	A.	21			90 in. s.	y., br. c.	
171	Helichrysum bracteatum	A.	4	A.	17	S.	4	25 in. s.	y.	
172	Helichrysum astrosanguineum	A.	3	A.	26	S.	8	23 in. s.	r. y. c.	Everlastings. Large flowers.
173	Helichrysum macranthum	Jl.	22	A.	11	S.	18	27 in. s.	l. r.	
174	Helipterum corymbiflorum	Jl.	13	Jl.	22	O.	18 +	10 in. s.	w.	Everlastings.
175	Helipterum Sanfordii	Jl.	10	Jl.	22	A.	23	14 in. s.	y.	
176	Hibiscus Africanus	Jl.	15	Jl.	28	S.	18	28 in. s.	y.	
177	Hibiscus, Golden Bowl	Jl.	20	A.	18	S.	30	32 in. s.	l. y.	Fine large flowers and good foliage.
178	Hieracium	Jl.	28	A.	10	S.	6	20 in. s.	w.	
179	Hieracium, Bearded	Jl.	24	A.	17	S.	8	17 in. s.	y.	
180	Humulus Japonicus	A.	17	A.	24	S.	8	96 in. tw.	l. green.	Very numerous inconspicuous flowers. A good vine.
181	Humulus J. variegatus	A.	17	A.	21	S.	10	96 in. tw.	l. green.	
182	Iberis affinis	Jl.	14	Jl.	28	O.	18 +	12 in. s.	w.	
183	Iberis amara	Jl.	10	Jl.	22	A.	31	14 in. s.	w.	
184	Iberis coronaria, Empress	Jl.	10	Jl.	22	S.	9	13 in. s.	w.	
185	Iberis c., White Rocket	Jl.	10	Jl.	22	S.	6	13 in. s.	w.	Candytuft.
186	Iberis sweet-scented	Jl.	14	Jl.	24	S.	18	15 in. s.	w.	
187	Iberis umbellata	Jl.	10	Jl.	22	A.	17	14 in. s.	d. r.	Very showy profuse bloomers. Of easiest culture.
188	Iberis umbellata	Jl.	10	Jl.	22	A.	28	14 in. s.	l. b.	
189	Iberis u. carnea	Jl.	13	Jl.	22	A.	28	14 in. s.	l. r.	
190	Iberis u. lilacina	Jl.	10	Jl.	22	A.	17	13 in. s.	l. b.	
191	Impatiens, Red stalk	A.	3	A.	16	O.	18	30 in. s.	r.	
192	Impatiens, Double	Jl.	24	Jl.	28	O.	18	30 in. s.	w.	

Names of plants.	First bloom.	Full bloom.	Last bloom.	Height and habit.	Color.	Remarks.
193 Impatiens Dbl. Pomegranate	Jl. 22	Jl. 28	O. 18	30 in. s.	r.	Balsams. Very profuse bloomers of fine color. Well known and popular.
194 Impatiens Dbl. Pomegranate	Jl. 21	Jl. 28	O. 18	30 in. s.	l. y.	
195 Impatiens Dbl. Pomegranate	Jl. 24	A. 2	O. 18	30 in. s.	w., b. s.	
196 Impatiens Dbl. Pomegranate	Jl. 22	Jl. 28	O. 18	30 in. s.	d. b.	
197 Impatiens Dbl. Pomegranate	Jl. 21	Jl. 28	O. 18	30 in. s.	w. & l. b.	
198 Impatiens double	Jl. 21	Jl. 28	O. 18	30 in. s.	w.	
199 Impatiens double	Jl. 21	Jl. 28	O. 18	30 in. s.	l. r.	
200 Impatiens double	Jl. 22	Jl. 28	O. 18	30 in. s.	r., w. s.	
201 Impatiens camellia-flowered	Jl. 20	Jl. 28	O. 18	30 in. s.	r.	
202 Impatiens camellia-flowered	Jl. 25	Jl. 31	O. 18	30 in. s.	l. b.	
203 Impatiens camellia-flowered	Jl. 21	Jl. 28	O. 18	30 in. s.	d. b.	
204 Impatiens camellia-flowered	Jl. 21	Jl. 28	O. 18	30 in. s.	w., r. s.	
*205 Ipomœa coccinea	A. 16	S. 5	O. 28	96 in. tw.	r., d. c.	Morning Glories. Always excellent. Fine in foliage and flower.
206 Ipomœa coccinea lutea	Jl. 13	A. 26	S. 27	96 in. tw.	y.	
*207 Ipomœa scarlet	A. 15	S. 5	O. 28	96 in. tw.	l. r.	
*208 Ipomœa hederacea	A. 24	S. 15	S. 28	96 in. tw.	w.	
*209 Ipomœa hederacea	A. 24	S. 10	S. 28	48 in. tw.	w.	
210 Ipomœa hederacea marmorata	Jl. 14	A. 10	S. 18	96 in. tw.	l. b.	
211 Ipomœa limbata	Jl. 10	A. 12	S. 27	96 in. tw.	b., w. s.	
*212 Ipomœa limbata	A. 23	S. 3	S. 28	96 in. tw.	l. r.	
213 Ipomœa Nil	Jl. 10	A. 28	S. 27	96 in. tw.	b.	
*214 Ipomœa purpurea			S. 28	96 in. tw.	w. s. l.	
*215 Ipomœa volubilis	A. 23	S. 17	S. 28	96 in. tw.	r.	
*216 Ipomœa volubilis	A. 23	S. 1	S. 28	96 in. tw.	d. r.	
*217 Ipomœa volubilis	A. 23	S. 15	S. 28	96 in. tw.	d. r.	
218 Kaulfussia amelloides	Jl. 13	Jl. 22	A. 13	8 in. s.	b.	Fine, but of short duration.
219 Kaulfussia a. atroviolacea	Jl. 21	Jl. 28	A. 28	9 in. s.	b.	
220 Kaulfussia a. kermesina	Jl. 21	Jl. 31	A. 16	9 in. s.	b.	
221 Lagenaria vulgaris, Bottle gourd	Jl. 31	A. 12	S. 13	96 in. c.	w.	

222	Lavatera alba	Jl. 22	Jl. 28	O. 18+	40 in. s.	w.	
223	Lavatera trimestris	Jl. 21	A. 3	O. 18	36 in. s.	l. r.	Large cup-shaped flowers.
224	Leptosiphon androsaceus	Jl. 13	Jl. 22	S. 18	12 in. s.	w.	
225	Leptosiphon carmineus	Jl. 13	Jl. 22	S. 13	14 in. s.	d. r.	
226	Leptosiphon densiflorus	A. 2	A. 5	S. 8	10 in. s.	b.	Good for edging.
227	Leptosiphon d. albus	Jl. 21	Jl. 28	S. 30	12 in. s.	w.	
228	Leptosiphon hybridus	Jl. 10	Jl. 22	O. 1	8 in. s.	w.	
229	Linaria bipartita splendida	Jl. 15	Jl. 30	S. 18	9 in. s.	d. b.	
230	Linaria Maroccana		Jl. 22	A. 16	8 in. s.	r.	
231	Linum grandiflorum	Jl. 21	A. 28	O. 18	21 in. sp.	r.	Dense, bushy foliage.
232	Loasa tricolor	Jl. 20	Jl. 31	A. 31	22 in. sp.	y.	Curious flowers and foliage.
*233	Lobelia Erinus	Jl. 29		O. 28	8 in. sp.	l. b.	
*234	Lobelia Erinus, Elegant	A. 14	S. 1	O. 28	8 in. sp.	l. b.	Good for edging.
235	Lupinus albus	Jl. 13	Jl. 22	S. 18	21 in. s.	w.	
236	Lupinus hirsutus	Jl. 13	Jl. 28	S. 18	20 in. s.	r.	
237	Lupinus h. pilosus	Jl. 13	Jl. 28	S. 27	25 in. s.	b.	
238	Lupinus nanus	Jl. 28	A. 10	O. 18	15 in. s.	l. b.	
239	Lupinus pubescens	Jl. 13	A. 28	O. 18	20 in. s.	w.	
240	Lupinus sulphureus	Jl. 13	A. 2	O. 18	16 in. s.	y.	
241	Madia elegans	Jl. 28	A. 3	O. 18	36 in. s.	y., b. e.	Very numerous conspicuous flowers.
242	Malope grandiflora	Jl. 14	Jl. 28	O. 18	15 in. s.	w. l. r.s.	Numerous mallow-like flowers.
243	Malope g. alba	Jl. 14	Jl. 28	O. 18	18 in. s.	w.	
244	Martynia craniolaria	Jl. 13	Jl. 21		36 in. s.	w., r. s.	Curious flowers and fruit.
245	Martynia formosa	Jl. 13	Jl. 21		36 in. s.	w.	
246	Martynia lutea	Jl. 15	Jl. 24		36 in. s.	y.	
247	Martynia proboscidea	Jl. 10	Jl. 24		36 in. s.	w. l.b.s.	
248	Matricaria eximia plena	A. 14	A. 28	S. 17	22 in. s.	w.	
249	Matthiola crimson	Jl. 13	Jl. 22	O. 18+	23 in. s.	r.	
250	Matthiola, Blood Red Ten Weeks	Jl. 13	Jl. 22	O. 18+	26 in. s.	d. r.	Stocks.
251	Matthiola, Cut and Come Again	Jl. 13	Jl. 22	O. 18+	25 in. s.	w.	Excellent for massing.
252	Matthiola, White Pearl	Jl. 15	Jl. 28	O. 18+	18 in. s.	w.	Fragrant. At their best in mid-
253	Matthiola grandiflora	Jl. 13	Jl. 22	S. 18+	24 in. s.	y.	season.
254	Matthiola grandiflora Dwarf	Jl. 14	Jl. 22	O. 18+	23 in. s.	r.	

Names of plants.	First bloom.	Full bloom.	Last bloom.	Height and habit.	Color.	Remarks.
255 Matthiola Light Blue	Jl. 13	Jl. 22	O. 18+	24 in. s.	l. b.	Stocks are always popular and worthy.
256 Matthiola Shining	Jl. 13	Jl. 22	O. 18+	23 in. s.	r.	
257 Matthiola, Giant Perfection	Jl. 9	Jl. 21	O. 18+	18 in. s.	w.	
258 Matthiola, Dresden Perpetual	Jl. 13	Jl. 22	O. 18+	23 in. s.	w.	
259 Matthiola, Double White Perfection	Jl. 13	Jl. 20	O. 18+	23 in. s.	w.	
260 Matthiola, Dwarf	Jl. 13	Jl. 22	O. 18+	24 in. s.	l. r.	
261 Matthiola, annuus	Jl. 13	Jl. 22	O. 18+	24 in. s.	r.	
262 Matthiola, Dwarf Forcing Snowflake	Jl. 15	Jl. 22	O. 18+	12 in. s.	w.	
263 Matthiola, Dwarf	Jl. 13	Jl. 22	S. 27	20 in. s.	l. r.	
264 Matthiola, Dwarf, Large-flowering	Jl. 14	Jl. 22	O. 18+	20 in. s.	w.	
265 Matthiola, Dwarf, Large-flowering	Jl. 15	Jl. 22	O. 18+	24 in. s.	w.	
266 Matthiola, Wallflower-leaved	Jl. 13	Jl 22	S. 30	11 in. s.	w.	
267 Matthiola, Wallflower-leaved	Jl. 13	Jl. 22	O. 18+	16 in. s.	r.	
268 Virginian Stock, Crimson King	Jl. 15	Jl. 22	O. 2	17 in. sp.	r.	
269 Virginian Stock	Jl. 13	Jl. 22	O. 18+	14 in. sp.	w.	Distinct from the ordinary stock.
270 Virginian Stock	Jl. 13	Jl. 22	O. 18+	14 in. sp.	l. r.	
271 Matthiola, biconis	Jl. 13	Jl. 21	S. 15	18 in. sp.	w.	
272 Mesenbryanthemum crystallinum	Jl. 30	A. 28	S. 18	10 in. sp.	w.	Curious plant. Inconspicuous flowers.
*273 Mimulus cupreus	Jl. 26	A. 14		9 in. sp.	w.	
274 Mirabilis alba	Jl. 28	A. 3	S. 30	15 in. s.	w.	The Four O'clocks; old and well known
275 Mirabilis Jalapa folio variegata	Jl. 28	A. 5	S. 28	26 in. s.	w.	
276 Mirabilis longiflora alba	Jl 30	A. 6	S. 30	26 in. s.	w.	
*277 Momordica elaterium	Jl. 25	A. 14	O. 28	13 in. sp.	y.	Fruits conspicuous and interesting.

278 Nigella	Jl. 21	Jl. 28	S. 2	16 in. s.	b.	
279 Nigella	Jl. 30	A. 3	S. 27	12 in. s.	w.	Very fine in foliage and flower.
280 Nigella, fl. pl	Jl. 21	Jl. 28	S. 1	16 in. s.	w.	
281 Nemophila atomaria	Jl. 13	Jl. 28	A. 28	6 in. sp.	w.	
282 Nemophila a. oculata	Jl. 14	Jl. 28		10 in. sp.	b.	Nemophilas are good for edgings.
283 Nemophila discoidalis	Jl. 14	A. 2	A. 21	5 in. sp.	d. b.	Pretty.
284 Nemophila insignis	Jl. 13	Jl. 24	O. 18	6 in. sp.	b., w. e.	
285 Nemophila i. alba	Jl. 14	Jl. 28	O. 18	8 in. sp.	w.	
286 Nemophila maculata	Jl. 13	Jl. 24	A. 28	6 in. sp.	s.	
287 Nemophila marginata	Jl. 13	Jl. 24		10 in. sp.	b., w. e.	
*288 Nolana atriplicifolia	Jl. 12	Jl. 29	O. 1	8 in. sp.	l. b.	
*289 Nolana atriplicifolia	Jl. 12	Jl. 29	O. 5	9 in. sp.	w.	
290 Nolana atriplicifolia alba	Jl. 15	Jl. 28		7 in. t.	w.	Stems and leaves fleshy.
291 Nolana lanceolata	A. 28			6 in. t.	b.	Make attractive mats on the ground.
292 Nolana paradoxa	A. 1			6 in. t.	b.	
*293 Nolana prostrata	Jl. 11	A. 14	O. 5	8 in. sp.	b.	
294 Omphalodes linifolia	Jl. 13	Jl. 22	S. 1	10 in. s.	w.	
*295 Oenothera Drummondii	A. 14	S. 5	O. 28	20 in. s.	y.	
*296 Oenothera Lamarckiana	S. 3		O. 28+	13 in. s.	y.	Flowers open at night.
*297 Oenothera rosea	Jl. 29	A. 30	O. 28+	12 in. s.	l. r.	
*298 Omothera tetraptera	Jl. 15	A. 18	O. 28+	10 in. s.	l. r.	
299 Palafoxia Hookeriana	Jl. 21	A. 3	A. 28	13 in. s.	l. r.	Everlasting.
300 Papaver, American Flag	Jl. 20	Jl. 24	S. 3	24 in. s.	r. and w.	
301 Papaver, Flag of Truce	Jl. 20	Jl. 24	A. 28	22 in. s.	w.	
302 Papaver, Irresistible	Jl 20	Jl. 28	A. 30			
303 Papaver, Mephisto	Jl. 19	Jl. 24	A. 31	20 in. s.	r.	
304 Papaver, The Mikado	Jl. 20	Jl. 28	A. 28	30 in. s.	w.	Poppies.
305 Papaver, Double	Jl. 19	Jl. 24	A. 27	26 in. s.	r.	
306 Papaver, Shirley	Jl. 13	Jl. 20	A. 20	15 in. s.	w.	Bedding plants. Large showy
307 Papaver cardinale	Jl. 22	Jl. 28	A. 30	18 in. s.	r.	flowers.
308 Papaver c. hybridiun	Jl. 19	Jl. 28	A. 27	21 in. s.	l. r.	
309 Papaver c., Danebrog	Jl. 19	Jl. 22	A. 23	20 in. s.	r.	Long stem on flowers.
310 Papaver glaucum	Jl. 13	Jl. 21	A. 7	15 in. s.	r.	
311 Papaver umbrosum	Jl. 19	Jl. 22	A. 28	18 in. s.	r.	
312 Perilla laciniata	A. 18	A. 21		30 in. s.		

	Names of plants.	First bloom.	Full bloom.	Last bloom.	Height and habit.	Color.	Remarks.
313	Perilla Nankinensis	A. 20	A. 26		27 in. s.		Foliage plants. Bronze-colored.
314	Petunia, Ring of Emerald	Ju. 28	Jl. 3	O. 9	14 in. sp.	d. b. and gr'n edge	
315	Phaseolus multiflorus	Jl. 13	Jl. 22	S. 27	96 in. tw.	r.	Very vigorous.
	Phlox Drummondii :—						
316	Phlox, Large flowering dwarf	Jl. 14	Jl. 24	O. 18+	12 in. sp.	d. r.	Bedding and border plants. Very profuse and long-flowering. Easy to grow.
317	Phlox, Dwarf Fireball	Jl. 20	Jl. 28	O. 18+	14 in. sp.	r.	
318	Phlox, Dwarf Bouquet	Jl. 20	Jl. 28	O. 18+	14 in. sp.	r.	
319	Phlox, Dwarf Snowball	Jl. 24	A. 3	O. 18+	12 in. sp.	w.	
320	Phlox grandiflora, half dwarf	Jl. 13	Jl. 24	O. 18+	15 in. sp.	br.	
321	Phlox, Black Warrior	Jl. 13	Jl. 22	O. 18+	15 in. sp.	d. r.	
322	Phlox, Rose	Jl. 15	Jl. 22	O. 18+	15 in. sp.	l. r.	
323	Phlox, Leopoldii	Jl. 13	Jl. 22	O. 18+	15 in. sp.	w and r.	
324	Phlox oculata alba	Jl. 15	Jl. 28	O. 18+	15 in. sp.	l. b., w. e.	
325	Phlox variabilis atropurpurea	Jl. 20	Jl. 24	O. 18+	15 in. sp.	b.	
326	Phlox grandiflora alba	Jl. 13	Jl. 22	O. 18+	15 in. sp.	w.	
327	Phlox grandiflora, Chamois Rose	Jl. 19	Jl. 24	O. 18+	15 in. sp.	l. r.	
328	Phlox grandiflora, Eclipse		Jl. 28	O. 18+	15 in. sp.	b.	
329	Phlox grandiflora kermesina splendens	Jl. 14	Jl. 24	O. 18+	15 in. sp.	d. r.	
330	Phlox g. stellata splendens.	Jl. 19	Jl. 24	O. 18+	15 in. sp.	r.	
331	Phlox cuspidata	Jl. 14	Jl. 24	O. 18+	15 in. sp.		
332	Podolepis affinis	Jl. 22	A. 2		8 in. sp.	y.	
333	Podolepis chrysantha	Jl. 16	A. 12	O. 18+	7 in. sp.	y.	
334	Portulaca, Carnation striped	Jl. 18	Jl. 28	O. 3	8 in. sp.	r. s.	Edging and bedding plants. Free-flowering. Flowers open in sunlight ; need dry soil.
335	Portulaca, fl. pl	A. 9	A. 26	O. 3	8 in. sp.	d. y.	
336	Portulaca, fl. pl	A. 10	A. 17	O. 3	8 in. sp.	d. b.	
337	Portulaca, fl. pl	A. 9	A. 28	O. 3	8 in. sp.	l. r.	
338	Portulaca, fl. pl	A. 9	A. 16	O. 3	8 in. sp.	l. r. s.	
339	Portulaca, fl. pl	Jl. 16	Jl. 28	O. 3	8 in. sp.	d. r.	

340	Portulaca fl. pl.	A. 10	A. 27	O. 3	8 in. sp.	w.	
341	Portulaca albiflora	A. 9	A. 17	O. 3	8 in. sp.	w.	
342	Portulaca aurantiaca	A. 10	A. 17	O. 3	8 in. sp.	y.	
343	Rhodanthe maculata	A. 5	A. 12	S. 27	10 in. s.	r. and w.	
344	Rhodanthe m. alba	Jl. 16	A. 5	A. 30	9 in. s.	w.	Everlastings.
345	Rhodanthe Manglesii	Jl. 21	Jl. 28	A. 28	8 in. s.	r. and w.	
*346	Ricinus albus	Castor beans.			72 in. s.		Light green stems, foliage slightly darker.
*347	Ricinus communis				78 in. s.		Light green foliage, still lighter stems.
*348	Ricinus communis				66 in. s.		Dark green foliage, reddish stems.
*349	Ricinus Gibsoni				60 in. s.		Rich brownish red foliage.
*350	Ricinus sanguineus				72 in. s.		Light green foliage with red stems.
*351	Ricinus viridis				78 in. s.		Dark green foliage, reddish stems.
*352	Ricinus Zanzibariensis				72 in. s.		Light green foliage and stems.
*353	Salvia coccinea	A. 20	S. 5	O. 28+	32 in. s.	r.	
*354	Salvia farinacea	A. 14	S. 5	O. 28+	30 in. s.	l. b.	Very fine for bedding.
*355	Salvia Horminum	Jl. 28	A. 14	O. 28+	15 in. s.	l. r.	
*356	Salvia splendens	A. 14	S. 5	O. 28		d. r.	
357	Saponaria	Jl. 28	A. 17	O. 18	9 in. s.	r.	Numerous small flowers.
358	Saponaria Calabrica	Jl. 28	A. 17	O. 18	10 in. s.	r.	Very compact plants.
359	Schizanthus papilionaceus	Jl. 8	Jl. 22	S. 18	16 in. s.	b. e.	
360	Schizanthus pinnatus	Jl. 8	Jl. 22	S. 27	17 in. s.		Fine in foliage and flower.
361	Sedum coeruleum	Jl. 20	Jl. 24	S. 15	6 in. sp.	w.	Free-flowering.
*362	Schizanthus pinnatus	Jl. 15		O. 5	12 in. sp.	w.	
363	Silene Armeria	Jl. 10	Jl. 22	S. 3	10 in. sp.	r.	
364	Silene A. alba	Jl. 10	Jl. 22		10 in. sp.	w.	
365	Silene pendula	Jl. 14	Jl. 29		10 in. sp.	r.	Good for bedding.
366	Silene p. ruberrima	A. 26		S. 18	7 in. sp.	l. r.	
367	Specularia	Jl. 13	Jl. 28	O. 18	10 in. sp.	b.	Edging plants.
368	Statice superba	Jl. 20		O. 3	14 in. s.	w.	
*369	Statice Thouini	Jl. 12	A. 14		15 in. s.	w.	For bedding.
370	Tagetes, Eldorado	A. 3	A. 28	O. 5	24 in. s.	y.	
371	Tagetes, Pride of the Garden	Jl. 24	A. 2	O. 5	14 in. s.	y.	
372	Tagetes, dwarf	Jl. 13	A. 12	O. 5	13 in. s.	y. s.	Marigolds.

Names of plants.	First bloom.	Full bloom.	Last bloom.	Height and habit.	Color.	Remarks.
373 Tagetes, French	Jl. 13	A. 30	O. 5	30 in. s.	o.	Showy plants; color confined to yellow.
374 Tagetes, Nugget of Gold	A. 16		O. 5	24 in. s.	d. y.	
375 Tagetes erecta fl. pl.	A. 23	S. 3	O. 5	27 in. s.	y.	
376 Tagetes patula	Jl. 10	Jl. 24	O. 5	20 in. s.	y. s.	
377 Tagetes signata	Jl. 22	A. 12	O. 5	20 in. s.	l. y.	
378 Thunbergia alata	Jl. 30	A. 11	S. 27	60 in. tw.	w.	Twining plants with numerous small flowers. Good and interesting.
379 Thunbergia a. Bakeri	Jl. 31	A. 11	S. 18	60 in. tw.	w.	
380 Thunbergia a. Fryeri	A. 2	A. 12	S. 27	60 in. tw.	d. y.	
381 Thunbergia a. aurantiaca	Jl. 28	A. 12		60 in. tw.	d. y.	
382 Thunbergia a. sulphurea	Jl. 28	A. 17	S. 27	60 in. tw.	y.	
383 Tropaeolum dwarf, Tom Thumb	Jl. 8	Jl. 17	O. 18	13 in. sp.	d. r.	Nasturtiums. The "Tom Thumb" or dwarf varieties fine for bedding. Foliage and flowers good.
384 Tropaeolum dwarf	Jl. 7	Jl. 17	O. 18	13 in. sp.	r.	
385 Tropaeolum dwarf	Jl. 8	Jl. 17	O. 18	13 in. sp.	l. r.	
386 Tropaeolum dwarf	Jl. 13	Jl. 21	O. 18	13 in. sp.	very d. r.	
387 Tropaeolum dwarf, Ruby King	Jl. 8	Jl. 17	O. 18	13 in. sp.	d. r.	
388 Tropaeolum dwarf, Aurora	Jl. 7	Jl. 17	O. 18	13 in. sp.	l. r.	
389 Tropaeolum dwarf	Jl. 7	Jl. 17	O. 18	13 in. sp.	w.	
390 Tropaeolum dwarf, Lady Bird	Jl. 7	Jl. 21	O. 18	13 in. sp.	y.	
391 Tropaeolum dwarf, Crystal Palace Gem	Jl. 6	Jl. 17	O. 18	13 in. sp.	l. r.	
392 Tropaeolum dwarf	Jl. 6	Jl. 17	O. 18	13 in. sp.	l. r.	
393 Tropaeolum dwarf, Empress of India	Jl. 8	Jl. 17	O. 18	13 in. sp.	y.	
394 Tropaeolum dwarf	Jl. 6	Jl. 17	O. 18	13 in. sp.	l. y.	
395 Tropaeolum tall	Jl. 10	Jl. 22	O. 18	60 in. tw.	d. r.	
396 Tropaeolum tall	Jl. 10	Jl. 21	O. 18	60 in. tw.	d. y.	
397 Tropaeolum tall	Jl. 10	Jl. 22	O. 18	60 in. tw.	l. r.	
398 Tropaeolum tall, Schulzi	Jl. 13	Jl. 22	O. 18	60 in. tw.	y.	
399 Tropaeolum tall, Schillingi	Jl. 10	Jl. 21	O. 18	60 in. tw.	l. y.	

400	Tropaeolum tall	Jl.	10	Jl.	21	O. 18	60 in. tw.	y.	
401	Tropaeolum Lobbianum, Asa Gray	Jl.	13			O. 18	60 in. tw.	w.	
402	Tropaeolum L., Brilliant	Jl.	13	Jl.	22	O. 18	60 in. tw.	d. r.	
403	Tropaeolum L., Crown Prince of Prussia	Jl.	13	Jl.	22	O. 18	60 in. tw.	d. r.	
404	Tropaeolum L., Crystal Palace	Jl.	13	Jl.	22	O. 18	60 in. tw.	l. r.	
405	Tropaeolum L., fulgeus	Jl.	10	Jl.	22	O. 18	60 in. tw.		
406	Tropaeolum L., Lilli Smith	Jl.	10	Jl.	22	O. 18	60 in. tw.	d. r.	The tall kinds are amongst the best of climbing plants, and are particularly good for foliage effects; excellent for covering rough and waste places.
407	Tropaeolum L., Lucifer	Jl.	10	Jl.	22	O. 18	60 in. tw.	d. r.	
408	Tropaeolum Lobbianum	Jl.	13	Jl.	21	O. 18	60 in. tw.	d. r.	
409	Tropaeolum L., Queen Victoria	Jl.	10	Jl.	22	O. 18	60 in. tw.	r.	
410	Tropaeolum L., Spit-fire	Jl.	13	Jl.	22	O. 18	60 in. tw.	r.	
411	Tropaeolum majus	Jl.	13	Jl.	22	O. 18	60 in. tw.	r.	
412	Tropaeolum m., hemisphæricum	Jl.	8	Jl.	21	O. 18	60 in. tw.	d. y.	
413	Tropaeol'm m., Schuerianum	Jl.	10	Jl.	20	O. 18	60 in. tw.	s.	
414	Tropaeolum m.S., coccineum	Jl.	13	Jl.	22	O. 18	60 in. tw.	r.	
415	Tropaeolum, Mad. Gunter hybrids	Jl.	13	Jl.	21	O. 18	60 in. tw.		
416	Tropaeolum Canariense	Jl	13	Jl.	21	O. 18	96 in. tw.	y.	
417	Venidium calendulaceum	Jl.	10	Jl.	28	O. 18	15 in. sp.	y.	Somewhat succulent plant.
418	Verbena auriculæflora	Jl.	6	Jl.	22	O. 18—	15 in. sp.		
419	Verbena Italica striata	Jl.	6	Jl.	22	O. 18—	15 in. sp.	s.	Profuse flowering and of fine color
420	Verbena hybrida	Jl.	6	Jl.	22	O. 18—	16 in. sp.	d. r.	
421	Verbena h., Scarlet Defiance	Jl.	6	Jl.	22	O. 18—	15 in. sp.	r.	
422	Verbena, Black-blue	Jl.	6	Jl.	22	O. 18—	15 in. sp.	d.b., w.e.	
423	Verbena cœrulea	Jl.	6	Jl.	22	O. 18—	13 in. sp.	b., w. e.	Bedding plants.
424	Verbena Golden-leaved	Jl.	6	Jl.	22	O. 18—	7 in. sp.	b.	
425	Verbena	Jl.	6	Jl.	22	O. 18—	7 in. sp.	y.	
426	Vicia Gerardii	Jl.	16	Jl.	30	O. 18	22 in. c.	b.	Delicate foliage and good flowers
427	Viscaria Coeli-Rosa	Jl.	16	Jl.	28	O. 18—	14 in. s.	l. r.	Fine foliage and free flowering
428	Viscaria elegans picta	Jl.	15	Jl.	22	O. 18—	13 in. s.	l. r., d. e.	Bedding plants.
429	Viscaria oculata	Jl.	15	Jl.	22	O. 18—	13 in. s.	r., d. e.	

Names of plants.	First bloom.	Full bloom.	Last bloom.	Height and habit.	Color.	Remarks.
430 Viscaria o., alba	Jl. 14	Jl. 22	O. 18—	14 in. s.	w.	
431 Viscaria o., cœrulea	Jl. 14	Jl. 22	O. 18—	12 in. s.		Bell-shaped flowers. Pretty.
432 Whitlavia gloxinoides	Jl. 10	Jl. 22	A. 28	16 in. s.	b. and w.	
433 Whitlavia grandiflora	Jl. 10	Jl. 22	S. 15	18 in. s.	d. b.	
434 Whitlavia g. alba	Jl. 10	Jl. 22	A. 31	19 in. s.	w.	
435 Xeranthemum album	Jl. 24	A. 3	O. 18	21 in. s.	w.	Everlastings.
436 Xeranthemum annuum	Jl. 22	A. 3	O. 18	24 in. s.	d. b.	
437 Xeranthemum multiflorum	Jl. 24	A. 3	O. 18	22 in. s.	b.	
438 Xeranthemum m., album	Jl. 22	Jl. 28	O. 18	23 in. s.	w.	
439 Xeranthemum superbissimum, fl. pl	Jl. 21	A. 2	O. 18	24 in. s.	d. b.	
440 Zinnia dwarf, fl. pl	Jl. 13	Jl. 22	O. 18	21 in. s.	r.	Very profuse-flowering, bedding plants. Excellent for making heavy masses of color in the farther borders. The large kinds are coarse. Showy.
441 Zinnia dwarf, fl. pl	Jl. 13	A. 2	O. 18	18 in. s.	d. b.	
442 Zinnia dwarf, fl. pl	A. 11	A. 26	O. 18	20 in. s.	s.	
443 Zinnia dwarf, fl. pl	Jl. 13	Jl. 28	O. 18	20 in. s.	d. r.	
444 Zinnia dwarf, fl. pl	Jl. 30	A. 5	O. 18	18 in. s.	r.	
445 Zinnia dwarf, fl. pl	Jl. 13	Jl. 22	O. 18	22 in. s.	w.	
446 Zinnia elegans alba, fl. pl	Jl. 28	A. 12	O. 18	26 in. s.	w.	
447 Zinnia, Tom Thumb	Jl. 13	Jl. 28	O. 18	20 in. s.	o.	
448 Zinnia, Tom Thumb	Jl. 13	Jl. 28	O. 18	23 in. s.	w.	
449 Zinnia Haageana, fl. pl	Jl. 14	Jl. 28	O. 18	21 in. s.	y.	
450 Zinnia coccinia plena	Jl. 13	A. 3	O. 18	20 in. s.	d. r.	
451 Zinnia tall, fl. pl	Jl. 13	Jl. 22	O. 18	23 in. s.	d. r.	
452 Zinnia tall, fl. pl	Jl. 13	Jl. 22	O. 18	23 in. s.	r.	
453 Zinnia tall, fl. pl	Jl. 16	A. 9	O. 18	23 in. s.	l. r.	
454 Zinnia tall, fl. pl	Jl. 13	A. 3	O. 18	23 in. s.	b.	
455 Zinnia tall, fl. pl	Jl. 13	Jl. 22	O. 18	23 in. s.	d. b.	
456 Zinnia tall, fl. pl	Jl. 13	Jl. 22	O. 18	23 in. s.	l. r.	
457 Zinnia tall, fl. pl	Jl. 13	Jl. 22	O. 18	23 in. s.	d. y.	
458 Zinnia tall, fl. pl	Jl. 13	Jl. 22	O. 18	23 in. s.	b.	
459 Zinnia tall, fl. pl	Jl. 10	Jl. 22	O. 18	23 in. s.	y.	

Summaries.

The various flowers mentioned in the foregoing tables are here classified for the convenience of the cultivator. In the color groups, those kinds which have given most satisfaction at Ithaca are printed in Italics; and these judgments are made with the coöperation of C. E. Hunn, gardener to the Horticultural Department.

Blue flowers.—Nos. *1*, *2*, *10*, *11*, 24, *26*, *27*, *49*, *50*, 51, 79, *82*, 84, *85*, 106, 110, 120, 131, 132, *138*, 141, *143*, 146, 159, *188*, *190*, 196, 202, 203, 204, 210, 211, 213, 218, *219*, 220, 229, *233*, *234*, 237, 238, 255, *278*, 282, 283, 284, 287, 288, 291, 292, 293, 314, 324, *325*, 328, 336, *354*, *367*, *422*, *423*, *424*, 426, *432*, 433, 436, 437, 439, 441, 454, 455, 458.

Orange flowers.—Nos. 28, 34, 35, 122, 126, 127, 373, 447.

Red flowers.—Nos. 4, 5, 7, 8, 13, *29*, 30, 31, 43, 44, 45, 55, 57, 67, *71*, *72*, 80, *86*, 100, *102*, *103*, *109*, 111, 112, 113, 114, 124, 133, *135*, 140, 147, 148, 151, 152, 153, 154, 155, 156, 158, 172, 173, 187, 189, 191, 193, 199, 200, 201, *205*, 209, 212, 215, *216*, 217, 223, 225, 230, 231, 236, 249, *250*, *254*, 256, 260, *261*, 263, 267, 268, 270, 297, 298, 299, *303*, *305*, *307*, 308, 309, 310, 311, *315*, *316*, *317*, 318, 320, *321*, 322, 327, 329, 330, 334, 337, 338, 339, *353*, 355, 356, *357*, 358, 363, 365, 366, *383*, *384*, *385*, 386, 387, 388, 391, 392, 395, 397, 402, 403, 404, 406, 407, 408, 409, 410, 411, 414, *420*, *421*, 427, 428, 429, *440*, *443*, 444, 450, 451, 452, 453, 456.

White flowers.—Nos. 3, 6, *9*, *18*, *19*, 22, 25, 36, 37, 46, 52, *56*, 60, 62, 64, 70, 73, 76, 77, 78, *81*, 83, 88, 92, 93, 94, 95, 96, 97, 99, *101*, *104*, 107, *108*, 115, 117, 118, 125, 130, 139, 142, 144, 145, 149, 150, 157, 174, 178, 182, *183*, 184, *185*, 186, 192, 195, 197, 198, 204, *208*, *209*, 221, *222*, 224, 227, 228, 235, 239, 242, *243*, 244, 245, 247, 248, *251*, *252*, *257*, *258*, 259, 262, 264, 265, 266, 269, 271, 272, 273, 274, 275, *276*, *279*, 280, 281, 285, 289, 290, 294, *301*, *304*, *306*, *319*, *323*, 326, 340, 341, 344, 361, 362, 364, 368, 369, 378, 379, 389, 401, 430, *434*, 435, 438, 445, 446, 448.

Yellow flowers.—Nos, 20, 21, 23, *32*, *33*, *38*, *39*, *40*, *41*, *42*, 47, 53, 54, 58, 59, 61, 63, 65, 66, 68, 69, *87*, 89, 90, 91, 98, 105, 119, 121, *123*, 128, 129, 134, 136, 137, 160–171, 175, *176*, *177*, 179, 194, *206*, *232*, 240, 241, 246, 253, 277, 295, 296, 332, 333, 342, *370*, 371, 372, 374, 375, 376, 377, *380*, *381*, 382, *390*, 393, 394, 396, *398*, 399, 400, 412, 416, 417, 425, 449 *457*, *459*.

Climbers.—Nos. 46, 81, 88–95 inclusive, 180, 181, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 221, 315, 378, 379, 380, 381, 382, 395–416 inclusive, 426.

Plants six to eight inches high.—Nos. 2, 148, 159, 281, 283, 284, 286, 291, 292, 361; 19, 43, 290, 333, 366, 424, 425; 151, 152, 218, 228, 230, 233, 234, 285, 288, 293, 332, 334–342 inclusive, 345.

Nine to twelve inches high.—Nos. 22, 76, 77, 149, 219, 220,

229, 273, 289, 344, 357 ; 18, 24, 31, 49, 75, 79, 150, 153, 157, 174, 226, 272, 282, 287, 294, 298, 343, 358, 363, 364, 365, 367 ; 44, 57, 154, 156, 158, 266 ; 83, 84, 86, 126, 137, 143, 144, 155, 182, 224, 227, 262, 279, 297, 316, 319, 362, 431.

Thirteen to seventeen inches high.—Nos. 1, 25, 26, 27, 80, 102, 116, 133, 184, 185, 190, 277, 296, 299, 372, 383–394 inclusive, 423, 428, 429 ; 28, 29, 30, 105, 113, 117, 118, 119, 127, 128, 129, 134, 175, 183, 187, 188, 189, 225, 269, 270, 314, 317, 318, 368, 371, 427, 430 ; 82, 85, 101, 103, 104, 106–112 inclusive, 114, 115, 120, 124, 139, 145, 186, 238, 242, 274, 306, 310, 320–331 inclusive, 355, 369, 417 418, 419, 421, 422 ; 3, 38, 123, 125, 240, 267, 278, 280, 359, 420, 432 ; 4, 5, 6, 62, 179,

Eighteen to twenty-three inches high.—Nos. 14. 39, 50, 52, 53, 55, 99, 136, 138, 146, 243, 252, 257, 271, 307, 311, 433, 441, 444 ; 32, 87, 135, 205, 434 ; 7, 8, 33, 36, 60, 61, 100, 140, 147, 178, 236, 239, 263, 264, 295, 303, 309, 376, 377, 442, 443, 447, 450 ; 45, 231, 235, 308, 435, 440, 449 ; 40, 56, 63, 68, 132, 232, 248, 309, 426, 437, 445 ; 172, 249, 254, 256, 258, 259, 438, 448, 451, 452, 453, 454, 455–459 inclusive.

Twenty-four to thirty inches high.—Nos. 11, 34, 37, 42, 46, 51, 59, 69, 131, 253, 255, 260, 261, 265, 300, 370, 374, 436, 439 ; 67, 171, 237, 251 ; 35, 47, 66, 122, 250, 275, 276, 305, 446 ; 173, 313, 375 ; 23, 71, 176 ; 96, 121, 142, 191–204 inclusive, 304, 312, 354, 373.

Thirty-one to forty inches high.—Nos. 9, 10, 20, 21, 58, 64, 65, 97, 142, 177, 353 ; 15, 48, 54, 70, 73, 95, 98, 130, 166, 169,223, 241, 244 ; 5, 6, 7.

Forty-one inches and above.—Nos. 8, 88–94 inclusive, 160–168 inclusive, 170, 180, 181, 205–217 inclusive, 221, 315, 346–352 inclusive, 378–382 inclusive, 395–416 inclusive.

Kinds desirable for borders or edging.—Nos. 18, 19, 24, 25, 74–79 inclusive, 101–119 inclusive, 159, 182–190 inclusive, 224, 225, 226, 227, 228, 233, 234, 278–287 inclusive, 334–342 inclusive, 357, 358, 367.

Good for bedders.—Nos. 7, 8, 9, 10, 11, 23, 28, 29, 32–45 inclusive, 48–53 inclusive, 60–69 inclusive, 82–87 inclusive, 99–120 inclusive, 123–129 inclusive, 133–136 inclusive, 138–158 inclusive, 176, 177, 182-204 inclusive, 222, 223, 231, 241, 242, 243, 248–271 inclusive, 278, 279, 280, 295, 296, 297, 298, 300–311 inclusive, 314, 316–331 inclusive, 334–342 inclusive, 353, 354, 355, 356, 359, 360, 363, 364, 365, 366, 370–377 inclusive, 383–394 inclusive, 418–424 inclusive, 427–431 inclusive, 440–459 inclusive.

Kinds in bloom at Ithaca after the first frost.—Nos. 1, 2, 7, 8, 20, 21, 32–39 inclusive, 43, 44, 45, 47, 49, 50, 51, 54, 55, 56, 58, 59, 61, 82–86 inclusive, 101–129 inclusive, 133, 134, 135, 136. 139, 141, 142, 143, 146–150 inclusive, 152, 153, 154, 157, 159, 174, 182, 222, 249–262 inclusive, 264, 265, 267, 269, 270, 296, 297, 298, 316–333 inclusive, 353, 354, 355, 418–431 inclusive.

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Cornell University Agricultural Experiment Station.

ITHACA, N. Y.

The Period of Gestation in Cows.

By HENRY H. WING.

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THE PERIOD OF GESTATION IN COWS.

Since 1889, observations of the period of gestation have been regularly made on all the cows in the University herd. The herd has contained an average of about twenty cows, about two-thirds Holstein and high grade Holstein, and one-third Jersey and high grade Jersey with a few native, mixed, and cross bred cattle. Nearly all the animals were bred and raised on the farm from dams so bred and raised. So that the observations were taken from a single herd and its descendants. In all, 194 observations have been made; of these, 9 terminated in the birth of dead calves prior to 253 days of pregnancy and three more were doubtful so that the 12 have been excluded and the averages confined to the 182 births that may be considered normal. The number of days required for gestation in each of these cases, and the sex of the offspring, is shown in Table I.

TABLE I.

Period of gestation days.	Number of cows.	Number of cow calves.	Number of bull calves.	Number of twin calves.
264	1	1		
267	1	1		
268	3	1	2	
271	4	1	3	
272	1		1	
273	5	1	2	2*
274	11	4	6	1†
275	10	4	6	
276	13	4	9	
277	15	9	5	1†
278	9	3	5	1*
279	15	11	4	
280	15	10	5	
281	7	6	1	
282	10	5	5	
283	16	9	7	
284	11	2	9	
285	9	4	5	
286	8	3	5	
287	7	2	5	
288	3	2	1	
289	2	1	1	
290	1		1	
293	2	1	1	
294	2	1	1	
296	1	1		
	182	87	90	5

* Bull and cow calves.
† Two cow calves

AVERAGES OF TABLE I.

General average including twins	182 births	280 days
Average, bull calves	90 "	280 "
" cow calves	87 "	280 "
" twin calves	5 "	275 "
By breed affinity (exclusive of twin births).		
Holstein and Holstein grades	97 births	280 days
bull calves	51 "	280 "
cow calves	46 "	280 "
Jersey and Jersey grades	56 "	279 "
bull calves	28 "	279 "
cow calves	28 "	279 "
Mixed and cross bred	24 "	283 "
bull calves	11 "	284 "
cow calves	13 "	282 "
According to the age of dam (exclusive of twin births).		
From 2-year-old cows	26 births	278 days
bull calves	14 "	277 "
cow calves	12 "	278 "
From 3-year-old cows	31 "	280 "
bull calves	19 "	280 "
cow calves	12 "	280 "
From 4-year-old cows	29 "	281 "
bull calves	16 "	281 "
cow calves	13 "	282 "
From cows 5-year-old and over	90 "	280 "
bull calves	40 "	281 "
cow calves	50 "	280 "

In this summary fractions of days have been omitted which will account for some apparent discrepances.

The statements in text books as to the period of gestation in the cow are commonly drawn from Earl Spencer's tables* which are based on the period of gestation of 764 cows of the "Durham or improved short-horned breed" observed for several years previous to 1839. The averages are as follows:

General average, 764 births	283 days.
bull calves, 401 births	284 "
cow calves, 340 births	283 "
twin calves, 23 births	277 "

In commenting on the table Earl Spencer says: "It will be seen that the shortest period of gestation, when a live calf was

*On the Gestation of Cows, by the Right Hon. Earl Spencer, Jour. Royal, Agr. Society, I, 1840, p. 165.

produced, was 220 days, and the longest 313 days; but I have not been able to rear any calf produced at any earlier period than 242 days. Any calf produced at an earlier period than 260 days must be considered decidedly premature; and any period of gestation exceeding 300 days must also be considered irregular; but in this latter case the health of the produce is not affected."

While the number of observations which we have been able to make is not enough to allow of extensive generalizations, still it may be permissible to generalize somewhat till more extensive observations shall make possible more definite conclusions.

The average period of gestation with us has been almost exactly 280 days and is the same regardless of the sex of the offspring, which is contrary to the general belief, perhaps based on Earl Spencer's tables, that the male calf is carried from one to three days longer than the female. The shortest period we have observed is 264 days and the longest 296. This as would be expected from the much smaller number of observations is a much narrower range than was observed by Earl Spencer.

While as has been said the average period of gestation is almost exactly two hundred and eighty days, a close study of Table I will show that the great majority of births occur from the 274th to the 287th day inclusive and that within this period the births are fairly equally distributed. It would thus appear that there is a period of about two weeks on any day of which the chances are approximately equal that the gestation will end. The great practical importance of a knowledge of the period of gestation is of course in knowing when the gestation is likely to terminate so that the animal may receive the care and attention that is necessary. In studying the records of individual animals in this respect we have noticed that in very many cases there seems to be a characteristic peculiarity of the animal as to the period of gestation. We have noticed in some animals that the period of gestation is uniformly either considerably longer or considerably shorter than the average. In others that the same rule holds true except as to a single birth which may depart widely from all the other births of the same animal. While with still other animals the period of gestation varies very widely with the different births. This has seemed of so much interest that

we have given below the details of the gestation of twenty-one cows that have produced four or more calves, arranged in groups according to the above characteristics.

TABLE II.

A. Cows whose period of gestation has been fairly uniform and usually markedly longer or shorter than the average.

	Date	Sex of calf.	Period of gestation.
Mollie, born Sept. 25, 1899:			
	Sept. 25, 1891,	cow	——
	Sept. 10, 1892,	bull	285
	Sept. 3, 1893,	cow	281
	Oct. 14, 1894,	bull	283
	Sept. 11, 1895,	cow	285
	Oct. 24, 1896,	bull	284
	Sept. 14, 1897,	cow	280
	Sept. 9, 1898,	cow	294
			Avg. 285
Emma, born Sept. 20, 1890:			
	Feb. 2, 1893,	cow	284
	May 5, 1894,	bull	280
	Aug. 25, 1895,	cow	279
	Sept. 9, 1896,	bull	282
	Aug. 22, 1897,	bull	279
	Sept. 7, 1898,	cow	282
			Avg. 281
Pearl, born Sept. 10, 1888:			
	Aug. 5, 1890,	cow	267
	Sept. 1, 1891,	cow	274
	Sept. 16, 1892,	bull	279
	Sept. 3, 1893,	bull	280
	Aug. 21, 1894,	bull and cow	——
	May 11, 1896,	bull	278
	Mch. 25. 1897,	cow	278
			Avg. 276
Dora, born Sept. 1, 1891:			
	Aug. 27, 1893,	bull	268
	Aug. 30, 1894,	cow	278
	Sept. 5, 1895,	bull	274
	Nov. 20, 1896,	cow	274
	Dec. 25, 1897,	bull	273
	Dec. 2, 1898,	bull	275
			Avg. 274

B. Cows similar to group *A* except that one or two gestations have been markedly longer or shorter than the others. The divergent gestation is printed in Italics.

		Sex of calf.	Period of gestation.
Julia, born Oct. 6, 1891:			
	Sept. 18, 1893,	bull	283
	Oct. 24, 1894,	bull	284
	Oct. 12, 1895,	cow	293
	Sept. 10, 1896,	*cow*	*280*
	Oct. 10, 1897,	bull	288
	Sept. 24, 1898,	bull	286
			Avg. 286
Belva 2d, born Oct. 4, 1893:			
	Sept. 18, 1895,	*cow*	*277*
	Sept. 22, 1896,	bull	290
	Sept. 9, 1897,	bull	283
	Oct. 17, 1898,	bull	294
			Avg, 286
Cherry, born Sept. 21, 1893:			
	Sept. 18, 1895,	bull	283
	Sept. 18, 1896,	bull	284
	Oct. 28, 1897,	bull	287
	Dec. 12, 1898,	*cow*	*279*
			Avg. 283
Freddie, born Aug. 28, 1885:			
	1887,	——	——
	1888,	——	——
	Sept. 4, 1889,	bull	287
	Sept. 18, 1890,	cow	287
	Oct. 6, 1891,	cow	288
	Sept. 15, 1892,	cow	283
	Aug. 23, 1893,	*bull and cow*	*273*
	Aug. 28, 1894,	*bull*	*274*
			Avg. 282
Pet, born Sept. 14, 1885:			
	1887,	——	——
	1888,	——	——
	Aug. 29, 1889,	bull	285
	Sept. 20, 1890,	cow	283
	Mch. 2, 1892,	cow	——
	Apr. 9, 1893,	*bull and cow*	*273*
	Apr. 11, 1894,	cow	285
	June 15, 1895,	cow	283
			Avg. 822

Beauty, age unknown :			
	Feb. 14, 1890,	bull	276
	Feb. 11, 1891,	cow	277
	Jan. 15, 1892,	bull	276
	Nov. 9, 1892,	bull	278
	Sept. 21, 1893,	cow	279
	Sept. 11, 1894,	*bull*	*287*
	Sept. 22, 1895,	cow	280
			Avg. 279
Gazelle, born Jan. 25, 1888 :			
	Sept. 6, 1890,	bull	275
	Feb. 8, 1892,	cow	278
	Dec. 1, 1892,	cow	275
	Oct. 25, 1893,	bull	277
	Sept. 24, 1894,	*bull*	*286*
	Aug. 27, 1895,	cow	279
			Avg. 278
Cora, age unknown :			
	Mch. 26, 1890,	cow	277
	Feb. 11, 1891,	bull	277
	Jan. 16, 1892,	cow	275
	Dec. 31, 1892,	bull	279
	Dec. 15, 1893,	*bull*	*283*
			Avg. 278
Daisy, born March 26, 1890 :			
	Sept. 20, 1891,	cow	——
	Sept. 22, 1892,	bull	274
	Sept. 13, 1893,	bull	275
	Sept. 12, 1894,	cow	277
	Sept. 21, 1895,	*cow*	*282*
			Avg. 277
Glista 4th, born Oct. 9, 1892 :			
	Oct. 17, 1894,	*bull*	*280*
	Sept. 2, 1895,	bull	272
	Sept. 12, 1896,	bull	274
	Sept. 28, 1897,	bull	276
	Sept. 8, 1898,	cow	277
			Avg. 276
Bertha, born Aug. 15, 1888 :			
	Oct. 17, 1890,	bull	278
	Sept. 16, 1891,	cow	268
	Oct. 7, 1892,	bull	275
	Sept. 30, 1893,	bull	274
	Sept. 17, 1894,	*cow*	*282*
	Aug. 30, 1895,	bull	276
			Avg. 275

C. Cows whose period of gestation has been variable.

		Sex of calf.	Period of gestation.
Garnet Valentine, born Sept. 2, 1891:			
	Aug. 18, 1893,	cow	abortion
	Aug. 30, 1894,	bull	273
	Aug. 31, 1895,	cow	285
	Aug. 29, 1896,	cow	276
	Sept. 13, 1897,	cow	285
			Avg. 280
Sadie, born March 2, 1892:			
	Mch. 21, 1894,	bull	280
	Mch. 10, 1895,	bull	287
	May 1, 1896,	cow and cow	274
	June 25, 1897,	cow	280
			Avg. 280
May 2d, born Nov. 20, 1892:			
	Sept. 16, 1894,	cow	271
	Sept. 13, 1895,	bull	279
	Sept. 28, 1896,	cow	279
	Sept. 11, 1897,	bull	283
	Dec. 18, 1898,	bull	284
			Avg. 279
Ruby, born Sept. 16, 1888:			
	Sept. 6, 1890,	cow	279
	Sept. 11, 1891,	cow	280
	Nov. 14, 1892,	cow and cow	277
	Feb. 22, 1894,	cow	283
	Jan. 31, 1895,	cow	286
	Dec. 24, 1895,	bull	283
	Dec. 26, 1896,	cow	281
	May 26, 1898,	bull	282
			Avg. 281
Gem Valentine, born Jan. 4, 1889:			
	Jan. 10, 1891,	bull	268
	Mch. 21, 1892,	cow	282
	Jan. 26, 1893,	cow	274
	Nov. 24, 1893,	bull	276
	Oct. 20, 1894,	bull	284
	Sept. 1, 1895,	cow	283
	Sept. 5, 1896,	bull	278
	Oct. 16, 1897,	bull	287
	Dec. 11, 1898,	bull	285
			Avg. 280

Belva, born Sept. 4, 1886:	1888,	——	——
	Sept. 8, 1889,	bull	275
	Aug. 14, 1890,	cow	280
	Oct. 2, 1891,	cow	286
	Sept. 26, 1892,	bull	278
	Oct. 4, 1893,	cow	279
	Sept. 16, 1894,	cow	284
			Avg. 280

It will be seen that the larger number of cows fall into the second group, i. e., those whose period of gestation is uniform with a single exception. Taking group *A* and group *B* together, it would seem that in the great majority of cases after a cow has had one or two calves it ought to be possible to predicate her period of gestation quite closely. It has already been shown that the gestations where twins have been carried, average quite a good deal shorter than when but one calf is born. This is true not only of our own observations but of Earl Spencer's as well. The difference is still more marked if the twin gestations are compared with the other gestations of the same animal as is shown in detail below.

TABLE III.

Comparison of Twin Gestations with other gestations of same cow.

		Sex of calf.	Days of gestation.
Freddie, born Aug. 28, 1885:			
	Sept. 4, 1889,	bull	287
	Sept. 18, 1890,	cow	287
	Oct. 6, 1891,	cow	288
	Sept. 15, 1892,	cow	283
	Aug. 23, 1893,	*bull and cow*	*273*
	Aug. 28, 1894,	bull	274
			Avg. 282
Pet, born Sept. 14, 1885:			
	Aug. 29, 1889,	bull	285
	Sept. 20, 1890,	cow	283
	Mch. 2, 1892,	cow	——
	April 9, 1893,	*bull and cow*	*273*
	April 12, 1894,	cow	285
	June 15, 1895,	cow	283
			Avg. 282

Ruby, born Sept. 16, 1888:

Sept. 6, 1890,	cow	279
Sept. 11, 1891,	cow	280
Nov. 14, 1892,	*cow and cow*	*277*
Feb. 22, 1894,	cow	283
Jan. 31, 1895,	cow	286
Dec. 24, 1895,	bull	283
Dec. 26, 1896,	cow	281
May 26, 1898,	bull	282
		Avg. 281

Sadie, born March 2, 1892:

Mch. 21, 1894,	bull	280
Mch. 10, 1895,	bull	287
May 1, 1896,	*cow and cow*	*274*
June 25, 1897,	cow	280
		Avg. 280

Glista Netherland, born Nov. 21, 1892:

Oct. 21, 1895,	bull	285
May 10, 1897,	cow	280
Sept. 1, 1898,	*bull and cow*	*278*
		Avg. 281

SUMMARY OF TABLE III.

	Average of all gestations days.	Average of all except twin gestation days.	Twin gestation days.
Freddie	282	284	273
Pet	282	284	273
Ruby	281	282	277
Sadie	280	282	274
Glista Netherland	281	282	278
Average	281	283	275

SUMMARY.

Of 182 births the average period of gestation was almost exactly 280 days.

The shortest period was 264 days; the longest 296 days.

Approximately equal numbers of births occurred on each day from the 274th to the 287th inclusive.

The period of gestation was the same for male and female calves.

The period of gestation where twins were born was five days less than the general average and eight days less than the average of the single births of the same cows.

Many cows show a well marked individual characteristic as to period of the gestation which may be several days longer or shorter than the average.

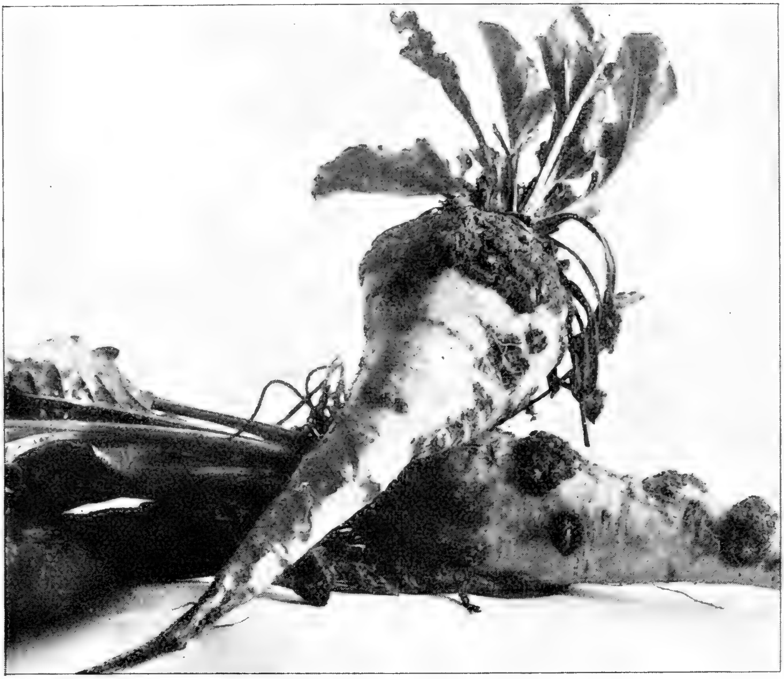
Bulletin 163. **February, 1899.**

Cornell University Agricultural Experiment Station.

ITHACA, N. Y.

BOTANICAL DIVISION.

THREE IMPORTANT FUNGOUS DISEASES OF THE SUGAR BEET.



By B. M. DUGGAR.

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CORNELL UNIVERSITY, ITHACA, N. Y., Feb. 3d, 1899.

THE HONORABLE COMMISSIONERS OF AGRICULTURE,

ALBANY, N. Y.

Sir:—The great awakening in the production of sugar beets naturally leads to a careful study of the diseases which effect them and which may, in many cases, seriously reduce the yield, therefore, it has been thought wise to make somewhat extended studies of some of the diseases of the sugar beet observed during the past season.

Mr. B. M. Duggar has made most careful investigations and studies of three diseases which are more or less prevalent. An attempt has been made to confine the work largely to those diseases which have proven to be of economic importance in this state. The "root rot" is a new disease in the Eastern states, but in the few localities where it was present during the past year it showed its possibilities for harm, and remedial measures should be at hand. This fungous is of special interest since it may cause diseases of other plants. The leaf spot of beets is ubiquitous in its occurrence, and in many localities it caused severe loss during the past season. The work here presented is the result of work in laboratory and field. The abundance and distribution of the diseases have received special attention in the field studies.

I. P. ROBERTS,

Director.

THREE IMPORTANT FUNGOUS DISEASES OF THE SUGAR BEET.

THREE IMPORTANT FUNGOUS DISEASES OF THE SUGAR BEET.

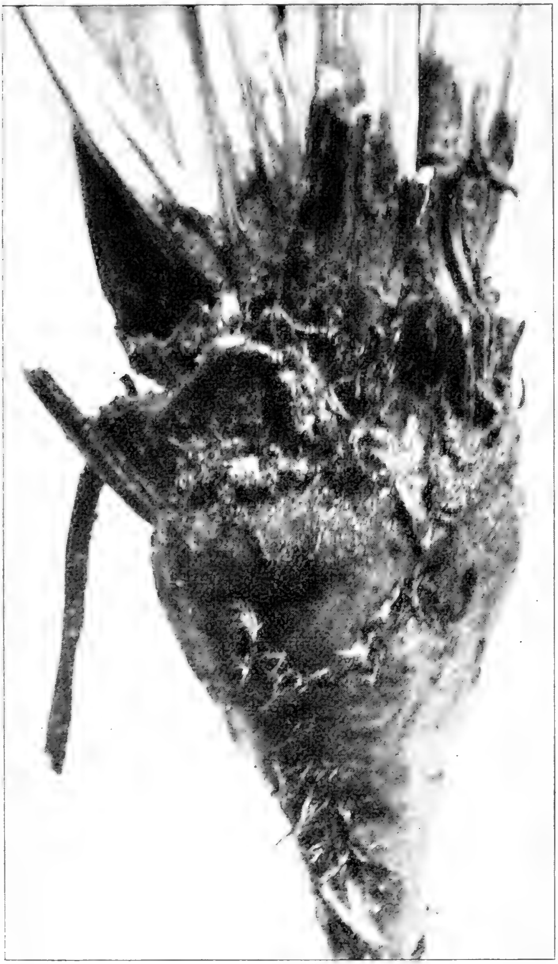
Many diseases of the sugar beet have been reported in the different countries where this crop is grown, and this is especially true of the old world, where the culture of sugar beets has formed an important industry throughout many years. Already there are three diseases in this state which should be well known to those interested in beet culture. When other diseases appear abundantly, they will also receive merited attention. The widespread distribution of beet culture during the past few years is necessarily attended by a greater distribution of the diseases. It is well at the start to know what these troubles are, and to know the methods of prevention. The losses from plant diseases are often as great, or greater, than losses due to neglect of the proper methods of culture; and as long as we must grow varieties susceptible to fungous diseases, the grower should prepare to combat these disease attacks just as efficiently as he is equipped to fulfil other necessary cultural requirements.

I. Root-Rot of Beets (*Rhizoctonia Betæ* Kühn.)

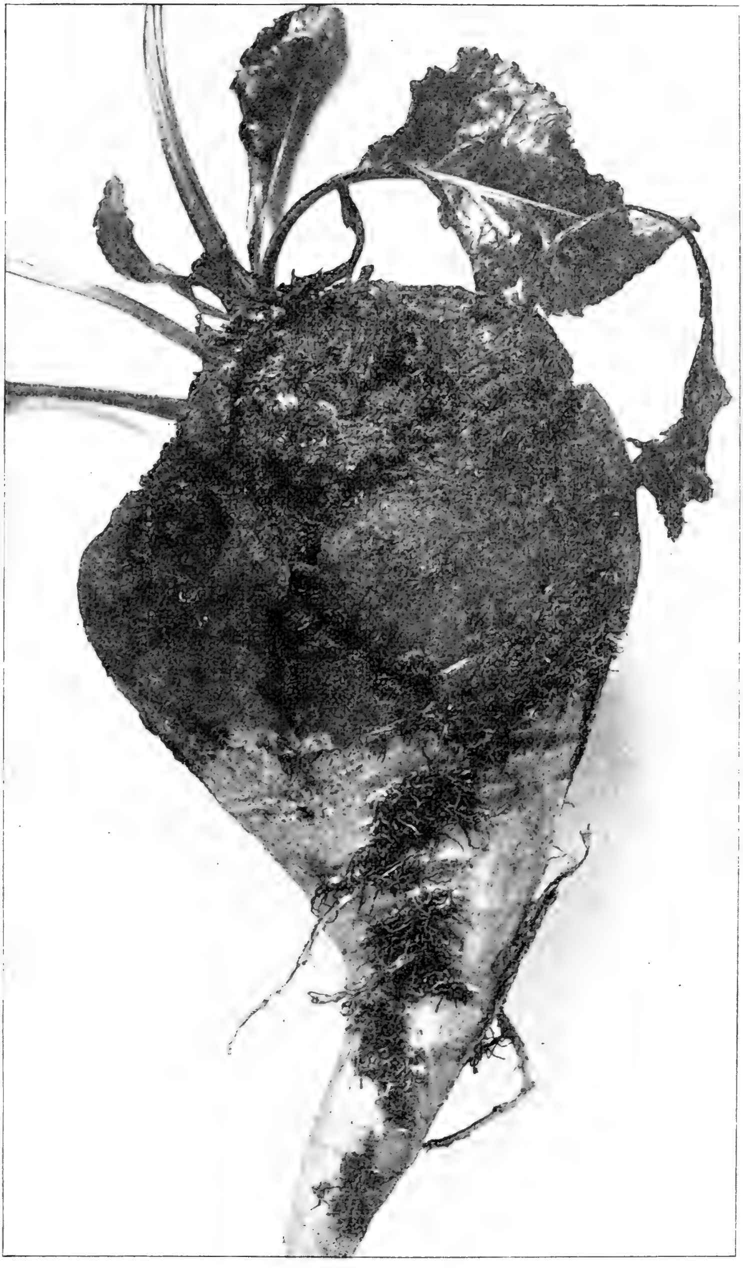
a. Occurrence of the Disease.

Beet root-rot was first brought to my attention as a disease of small extent in the vicinity of Binghamton. A few days afterwards it was found abundantly at Cattatonk, N. Y. A visit to the latter place on Aug. 12 demonstrated that the disease was a matter of considerable practical importance. An examination of a three-acre field on the premises of Philip Caple convinced me that probably one-third of the beets in this field were affected, and it was then too late to attempt any remedial measures with this root-rot. Fortunately, some change in the conditions soon checked it, and my notes represent the final effect of the disease. A careful study of the affected field showed one point of peculiar interest. In certain areas the chipped tan-bark of an

old tannery had been thickly spread on the land, and in such areas there was not the slightest indication of diseased beets, The tannery product was quite dry; and I attributed the absence of the disease to the lessened water content of the upper layers of the soil, which assumption would be in accordance with the results of some experiments to be detailed later. Again, in a part of the field where coal ashes had been heavily applied, there was a noticeable diminution in the amount of the disease. This disease was afterwards reported from several places in the state, although it has not yet proved a common disease in New York. As mentioned later, what is probably the same disease was reported in Iowa in 1891, and it may have been



49.—*An early stage of the attack of Beet Root-Rot. The basal parts of the leaves are blackened.*



50.—*A late stage of Beet Root-Rot, showing the cracking and rotting of the root.*

observed in one or two other sections of the country. It may be the same trouble that has several times been very destructive to the sugar beet industry in Germany. Again, as subsequently noted, this beet root-rot is caused by the same fungus which causes a stem rot of carnations; and probably by the same fungus which produces some damping off diseases, so that we may predict that it has a wide distribution even at the present time.

b. Appearance of Affected Plants.

Under favorable conditions for its spread, this beet root-rot generally secures its first foothold at the bases of the leaves. These parts are moist with the slightest rain or dew, and inoculation experiments show that in those regions the disease "takes" very readily. The first evidence of the attack is manifest in the blackening of these leaf bases, the outer leaves first, so that the stalks soon become unable longer to support the blades, and the leaves may lie prostrate on the ground. The leaves do not, however, lose their green color very readily. Figure 49 shows this blackening of the leaf bases, before any injury is manifest in the other parts.

The disease soon works into the crown and root proper, causing the infested parts to turn brown. With further spread of the fungus in the root region, cracks appear, as shown in figure 50. If the conditions continue to favor the disease, in time the whole top rots away, and the beet gradually disappears. Cold weather or dry conditions may so retard the disease that plants only slightly affected may recover entirely. Ordinarily the trouble was scattered throughout the entire field affected, but numerous small areas indicate that the fungus passes rapidly from plant to plant in the row, spreading radially.

Even when the bases of the leaves alone are affected, upon careful examination one will find that there are to be seen the brown mycelial threads of the fungus growing over the surface. After the root has become affected, a considerable weft of the fungus will be evident in the cracks. A diseased beet sliced lengthwise and placed in a moist chamber yields in a day or two a luxuriant growth of the mould-like hyphæ. From this outgrowth of mycelium it is very easy to secure a pure culture of

the fungus. Acidulated bean pods, or bean stems, as mentioned by Professor Geo. F. Atkinson, in his study of the sterile damping off fungus,* are excellent for this purpose. The fungus prefers an acid substance, while the ordinary bacteria of decay are shut out by such acidity. One drop of 50 per cent lactic acid to each test tube with the usual amount of medium is sufficient for best results.

If the beets are much rotted, one may find, even in the field, that the surface of roots in moist conditions is covered with a short, tuft-like growth of the fungus. I have not found that the blackened, crust-like, or more or less rounded, compact masses of the mycelium, called sclerotia, ever occur on beets in the field.

In this connection it may be well to state that all necessary cultures were made both from affected parts, and from the adjacent white meat of the beet, to determine the part that bacteria or other fungi might play in the etiology of the disease ; but no other parasitic organism was found. As Pammel has stated, bacteria are probably much concerned in the final rotting of the beet.

c. The Cause of the Beet Root-Rot.

The constant association of the brown fungus *Rhizoctonia* with the cracking and rotting of beets in the field was not taken as final evidence that this fungus caused the trouble, and although late in the season, a few experiments were undertaken to determine the degree of parasitism of the fungus, and the conditions under which it acted.

Experiment 1. In a short row of twenty-four half-grown beets eight were inoculated on Aug. 13. The inoculations were made by placing among the crown leaves fresh pieces of beet on which this fungus alone had been growing for a short time. The whole row was mulched with straw. The weather was wet for a few days only, but afterwards quite dry. On Sept. 2 eighteen beets in this row were affected by the rot.

Experiment 2. Six beets or clusters of beets were inoculated as in experiment 1, but over each inoculated area was placed a

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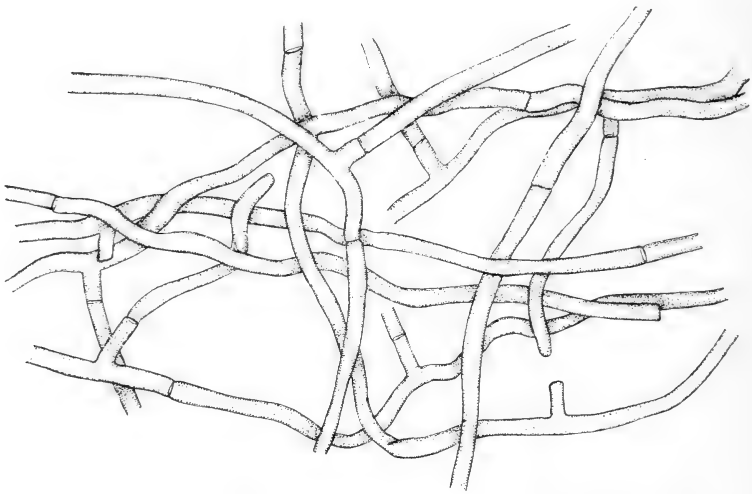
* Bulletin 94, Cornell Univ. Agl. Exp. Station, 1895.

large bell glass. On Sept. 2 all of the inoculated plants were diseased, but the trouble had not spread from the bell glasses.

Experiment 3. Twelve beets as above were inoculated, but with no provision for retaining moisture. On Sept. 2 nine of the inoculated plants were affected.

Experiment 4. Twelve beets were inoculated with a mixture of several bacterial forms isolated from diseased tissues and from



51.—*The brown hyphæ which invest the cracks on diseased beets.*

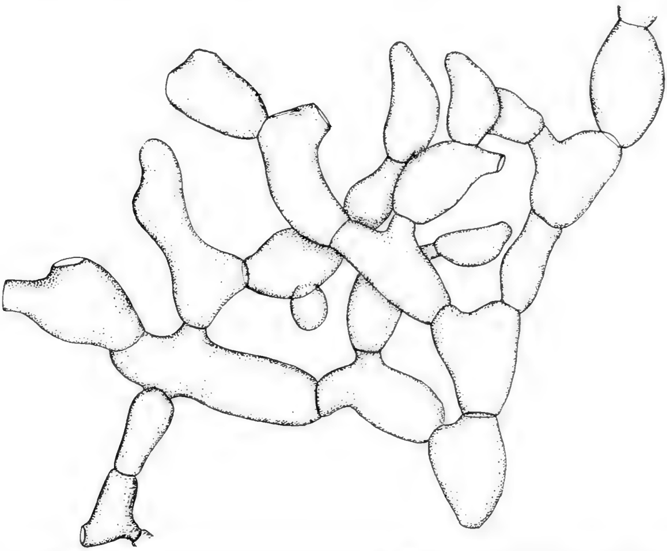
parts of the beet immediately below diseased areas. These beets remained healthy throughout the experiment.

Alternating with the rows experimented upon were check rows, all of the beets in which remained perfectly free from root-rot troubles.

These experiments indicated that the fungus *Rhizoctonia* readily produces root-1ot when the conditions are favorable, and that moist conditions are essential for the spread of the disease from plant to plant. Later experiments with pure cultures of the fungus growing on bean pods were used to inoculate seedling beets, and with such plants a damping off effect was produced.

d. Special Characters of the Fungus.

The morphological characters of the fungus may well be studied both from the mycelium found on the diseased beet, and from the growth in pure cultures, secured as above mentioned. In pure cultures on bean pods and on slices of sugar beet the fungus grows vigorously, and a loose mycelium first appears. However the fungus may be grown, it shows a very characteristic method of branching, which serves to identify it. In the young, vigorously growing hyphae the branches are inclined at an angle more or less acute with the direction of growth of the parent branch : and the point of union of the two is marked by a slight constriction. Invariably the branches are cut off by a septum at a distance of several micromillimeters from the parent branch. At first the mycelium is quite hyaline, and



52.—*The large, closely septate hyphae which make up the short tufted growth.*

strongly vacuolate ; but with age the loose hyphae may become very light brown in color. In the older hyphae of the loose growth it is noticeable that the constrictions at the places of union of the branches are not so evident, and this is especially true of the dark colored mycelium found externally in connection with the diseased area of the beet root, as in figure 51. In the cultures the loose growth is followed by a closer tufted growth of short hyphae. On such rich media as bean pods this close growth covers almost the entire surface, and little tufts may also appear on the glass of the test tube. This growth is at first somewhat mealy in appearance, but later it becomes deep brown in color. These tufts are made up of short

hyphae much larger in diameter than those previously mentioned. They are closely septate, and constricted at the septa. Usually they branch irregularly and profusely as in figure 52, but truly dichotomous branching is often observed, and long moniliform chains of cells are not infrequent. Such tufts of hyphae are also occasionally found on beets badly rotted in the field. With age these chain-like aggregations break into hyphal elements of a single cell or of several cells attached; and most of these cells may then function as conidia, producing on germination the characteristic mycelium first mentioned. In the manner of germination these cells are peculiar. The germ tube passes out through the septum originally separating the cell from its neighbor. As soon as the germ tube has grown to an extent equal to several times the length of the parent cell, a septum invariably forms at a short distance from the latter, the proximal cell is somewhat narrowed at its exit from the hyphal cell, and the first septum decides the normal diameter of the tube. When germination takes place from an inner one of several connected cells, a peculiar phenomenon occurs. The germ tube may pass from one cell into and through its adjacent neighboring cell; and usually such cells through which germ tubes pass seem to be themselves devoid of contents, or at least they lack the vacuolate structure of the germinating cells. These characters are shown in figure 53.

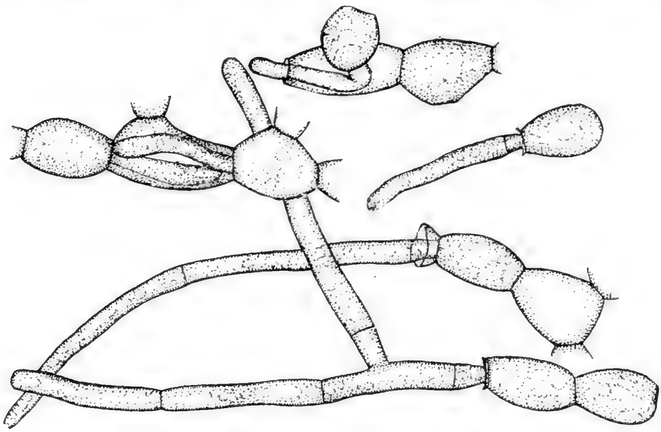
When this fungus is grown on bean stems or on other nutrient media not so rich as bean pods, crust-like sclerotial bodies are oftener formed. The sclerotia begin as a closely branched mass of filamentous hyphae, and by further growth these become so interwoven as to form a more or less compact body. Sclerotia have been more readily produced by making fresh cultures from pure cultures of the fungus which had been kept in the laboratory for a long time, the original cultures being made from damping off lettuce. In all cases, however, the hyphae and the sclerotia are very different from those of *Botrytis* and other allied fungi often causing rots and certain damping off diseases.

e. The Beet Root-Rot Fungus as a cause of Other Types of Plant Diseases.

While working with cotton diseases in Alabama in 1892, Professor Geo. F. Atkinson found that the so-called "sore shin" of seedling cotton plants is abundantly produced by sterile fungus. Some of the results of this work were published in Bulletin 41 of the Alabama Experiment Station. In his later work at this Experiment Station upon damping off fungi, the same fungus was again found to cause damping off of many seedlings, especially of lettuce, cabbage, radish, egg-plant, &c. Under the caption "Damping off by a Sterile Fungus," in Bulletin No. 94 of this

Experiment Station, the fungus was described in considerable detail.

During the past two years I have continued studies upon certain damping off fungi, and this sterile fungus has often been found as the cause of damping off in seedling lettuce, beans, and cucumbers, and occasionally in many other seedlings. That the fungus referred to is the cause of these troubles has been proved in the case of the lettuce and radishes by inoculation with pure culture. Seedlings affected by this fungus show the usual char-



53.—*Germinating cells of the Root-rot fungus.*

acteristics of damping off. The plants first show signs of weakness near the surface of the ground, the water-soaked tissues of this region are soon unable to support the plant, and it may fall prostrate on the surface of the ground, the fungus soon invading all parts. Among lettuce seedlings, especially, this fungus spreads rapidly from plant to plant ; and a box of seedlings may have the appearance of being wilted down, as in figure 54. Damping off diseases of seedlings which have been growing normally should not be confused with the simple wilting of seedlings in dry soil, or to the wilting due to the transfer of seedlings from a warm soil to a cold soil, etc.

In the winter of 1898 I received from a correspondent radishes of marketable size which showed a soft rot of the crown, or ulcerated areas in the region of the crown, as shown in figure 55.

54.—*A box of lettuce seedlings damping off by the sterile fungus.*

The leaves were usually unaffected until large portions of the fleshy roots had rotted. Cultures from diseased parts again yielded a fungus with structural characters exactly similar to those of the sore shin and damping off fungus.

When the beet fungus was first isolated and studied I was surprised to find a fungus agreeing in structural details with the one causing damping off, radish rot, &c. The growth characters of the fungi in pure culture were also practically the same, and experiments were soon instituted to determine if, under any circumstances, the beet fungus could cause damping-off. In the first experiments to determine this point, lettuce and radish seedlings were used. Small pieces of beet on which the beet fungus was growing profusely were put at definitely marked places in a large box of lettuce seedlings on Sept. 26. Similar inoculations were made in a box of radish seedlings, and in both instances checks were observed. On the second day, at every point where the the beet *Rhizoctonia* had been introduced a few lettuce seedlings were diseased, and in five days a considerable area about each piece had damped off. With the radish seedlings damping off was very slow, and no large number of seedlings succumbed; but in seven days a few plants were affected at about one-half of the inoculation centers. Subsequent work seems to indicate that the fungus from beets does not cause damping off of

55.—*Radishes affected with soft rot of the crown.*

a very violent kind, but that it may cause damping off of lettuce, cotton, and some other plants to a limited extent. Owing to the similarity in morphological characters of these forms of *Rhizoctonia* from the sources mentioned, and with the experimental evidence available, it seemed at first that these forms were exactly identical. Further evidence may indicate that we must recognize differences which are at least racial, not permitting of the ready transfer in a single generation of the beet fungus to seedlings of other plants, or vice versa.*

Mr. F. C. Stewart, of the Geneva Station, is at work upon a stem rot of carnations and the fungus causing this disease of carnations is identical in all morphological characters with the *Rhizoctonia* of beet root-rot. Experimental proof has also been established showing that the two diseases are due to the same organism ; and this evidence is detailed in the paper mentioned below.

From the work of Kühn and Pammel it is quite evident that the beet fungus should be referred to *Rhizoctonia Betæ* Kühn ; but at this time it is undesirable to enter into any discussion concerning the proper limitation of species in this genus which has been variously treated by Tulsane†, Comes‡, and others.

f. Remedies.

The use of lime as a possible preventive for certain rhizoctonial diseases has been recommended. The use of an alkali as a preventive might be logically suggested knowing the avidity with which the fungus grows on acidulated nutrient media. The failure of the *Rhizoctonia* to cause trouble in those parts of the field where coal ashes had been used abundantly again suggests the same remedy. Furthermore, Mr. F. C. Stewart has determined that a small amount of alkalinity is fatal

* Further details bearing upon the similarity of these forms of *Rhizoctonia* will be found in a paper presented before the Society of Vegetable Morphology and Physiology, Dec., 1898, entitled "Different Types of Plant Diseases Due to a Common *Rhizoctonia*," by B. M. Duggar and F. C. Stewart. This paper will soon be published in the Botanical Gazette.

† Tulasne, L. R. & C. Fungi Hypogæi, pp. 188—195.

‡ Comes, O. Crittogamia Agraria.

56.—*A beet leaf showing the early stages of injury due to the leaf spot fungus.* (*Photographed by Prof. Geo. F. Atkinson.*)

to the growth of the *Rhizoctonia* of carnations in cultures. In general it seems that the soils of the State are usually in need of liming, and where this beet disease appears it would be very well to make an application of lime. Sixty to seventy bushels of air-slaked lime per acre would be a cheap and effective means of securing the desired alkalinity. It would be preferable to make this application in the autumn, or at least before the ground is turned, so that the lime would be well distributed.

II. LEAF SPOT OF THE BEET (*Cercospora beticola* Sacc.).

a. General Account.

The above disease is one of very wide distribution. It has long been known both in this country and in Europe, and it probably occurs in all regions where beets are grown even to a limited extent. It is a well known disease of the red garden beet, but many of the garden varieties are so resistant that the disease is not there a matter of great concern. My observations in this State indicate that it is much more injurious to sugar beets, than to the red varieties, and much damage was done by it during the past year. For this reason it needs to be brought to the special attention of those interested in the culture of sugar beets.

The name well denotes the appearance of the disease, at least in the early stages. It begins as small brown spots with a reddish purple margin, these spots being scattered irregularly over the leaf, as in figure 56. The spots become ashen gray at the centers, with the border as before; and they may become so numerous as to cover a large portion of the surface of the leaf before there is any general discoloration of the blade. In time, however, the blade shows a parched appearance, begins to blacken gradually from the distal portions towards the stalk, and finally the whole leaf is black and crisp. As soon as the leaves begin to appear parched and dry, they stand more nearly upright on the crown, and a whole field badly affected with this disease makes a very characteristic appearance, as shown in figure 57. The individual blades that are badly affected are somewhat curled or rolled, and even this is slightly evident in the photograph.

57.—*A field of beets near Owego badly injured by the leaf-spot fungus; the curled and upright condition of the leaves indicate the trouble.*

The outer or older leaves are of course first affected, and after the leaf stalks wilt these leaves are shed. In the meantime the plant is endeavoring to supply this deficiency of leaves by continuing to develop new ones from the center, or from the bud. In consequence of this, the crown becomes considerably elongated, as in figure 58. During the past summer several fields of beets were observed in which the majority of the plants showed crowns thus elongated. If this is very marked, the roots are abnormally small, and much of the energy of the plant is evidently directed to saving itself. Even where the leaves are much less injured, it is undoubtedly a matter of economy to resort to preventive measures.

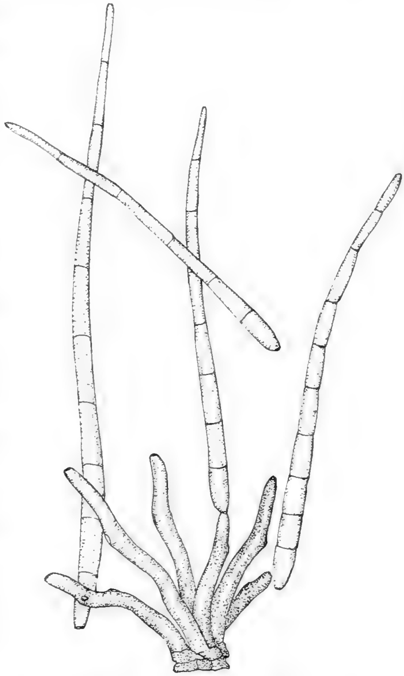
58.—*Prolonged crown of a beet which has been affected by the leaf-spot fungus.*

During the present season this disease has been especially abundant in the valleys along the streams, but there is every reason to believe that it is usually quite as abundant in the high land as in the low land. In the same field the conditions seem to make but little difference; it is found in the moist basins, and on the well-drained knolls.

Sorauer has stated that the leaf spot fungus is not confined to the leaves, that it is also to be found upon the bracts and peduncles of the flowers, and even upon the seed pods themselves. For this reason he thinks that the disease may be transmitted through the seed so as to be in readiness to affect young seedlings.

b. Characters of the Fungus.

The leaf spot of beets is caused by the fungus *Cercospora beticola* Sacc. When the spots on diseased leaves begin to look somewhat grayish in appearance, the reproductive or propagative parts of the fungus will be found abundantly. The upright blackened leaves often show this ashen appearance over the entire surface. Examining under the microscope a little of this material scraped off with the knife there will be found numerous clusters of short erect hyphae, such as are represented by the darker lower portion of figure 59. These hyphae bear the spores, or reproductive bodies, represented in the upper portion of the figure. These spores are carried about by the wind from diseased leaves to healthy leaves, and from diseased plants to healthy plants; where they fall they germinate, if the conditions are suitable; and on growing again within the tissues of the beet leaf they produce the characteristic spots.

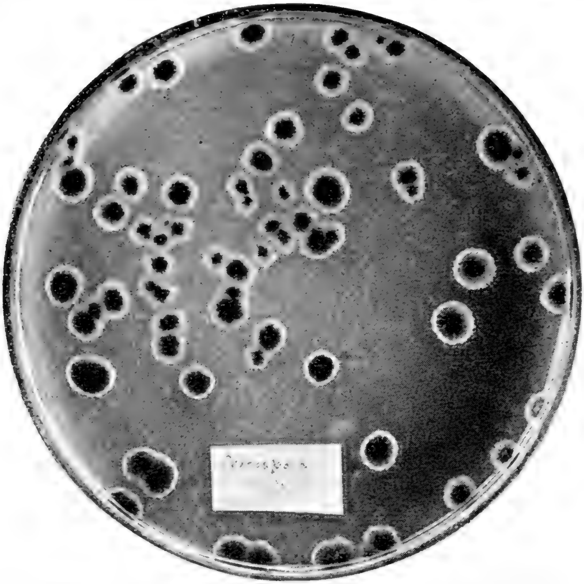


59.—*Fertile hyphae and spores of the leaf-spot fungus.*

The fertile hyphae are about 35–55x4–5.* The conidia vary considerably in size, but are usually 75–200x3.5–4.5,* although much longer if produced in very moist conditions, or in a moist chamber. Pure cultures of the fungus may be readily secured by the ordinary method of dilution culture. The colonies show up well in the petri dishes after a growth of a few days, as shown in figure 60. The mycelium grows in a close mat, deeply olivaceous in color. The aerial growth is also oblivaceous at first, and later it is grayish-green. Transfers to sterile bean pods have given excellent growths in pure culture. Cultures of the fun-

* Measurements expressed in micromillimeters.

gus have been kept in the laboratory for two years, and during this time some attempts have been made to secure any other stages that might be connected with the *Cescospora*, but in culture no fruiting forms have been secured. In studies of some other species of *Corcospora* more or less abnormal conidia* were produced, but with this beet fungus not even conidia are developed in cultures. There is a tendency for the aerial hyphae to adhere in clusters as they grow out from the substratum, as in the upper portion of figure 61, and from these hyphae branches arise as if to bear conidia, but none are produced. In the lower portion of figure 61 is represented some of the characteristic mycelium which grows immersed, abundant swellings and irregular branching occurring. A close inspection has been made of old diseased leaves during the autumn and winter, but no fungi have yet been found which seem to suggest a perfect stage of this *Cercospora*.



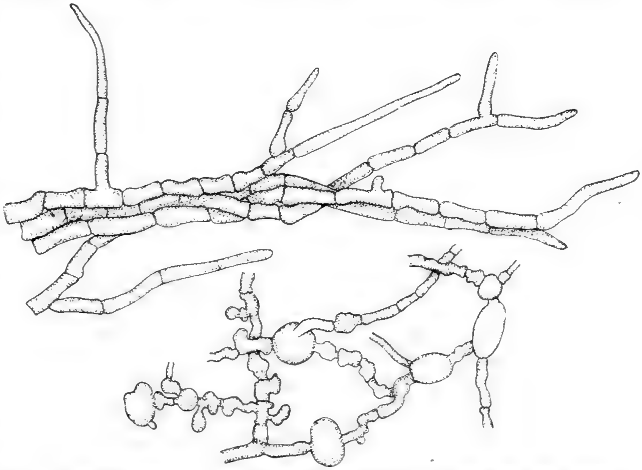
60.—*Petri dish culture of the leaf-spot fungus on agar.*

c. Remedies.

During the past season the serious injuries due to the leaf spot were not manifest until it was deemed too late to make satisfactory experiments with the use of fungicides for its prevention. For several years, however, experiments have been conducted by Professor Halsted, at the New Jersey Experiment Station, in the

*Compare, Early Blight of Celery, Bulletin 132 of this Station.

treatment of this disease, and a successful remedy seems to be at hand in the well-known Bordeaux mixture. Numerous fungicides were experimented upon, but the Bordeaux mixture has proved most efficient.



61.—*Mycelium of Cercospora beticola as grown in pure culture.*

There is every reason to believe that by beginning the sprayings early the leaf-spot may be almost entirely prevented by the use of this fungicide. If the disease continues so disastrous as it was in certain sections during the past season, for success growers must expect to spray their beets with the same regularity as has been found necessary in growing potatoes. The standard formula for the Bordeaux mixture should be used, consisting of:—

Copper sulfate (Blue Vitriol)	6 pounds
Fresh stone lime (unslaked)	4 "
Water	50 gallons.

Dissolve the copper in half of the water used, suspending the crystals in a sack in the water.

Slack the lime slowly, and then dilute to half the full quanity of water.

Pour one solution into the other, stirring constantly. Stir the mixture before using. If the potassium ferrocyanide test is not used, it might be well to add another pound of lime.

If by further experiment it should be shown that the disease is introduced abundantly by means of the seed, it will be necessary to treat the seed with hot water, copper sulfate solution, or some

other fungicide. That the seed of beets will readily withstand such treatment is shown in the following table :—

EFFECT OF HOT WATER AND COPPER SULFATE SOLUTION ON GERMINATION OF BEET SEED.

No.	Nov. 4, 100 seed treated with	Time.	Plants germ. Nov. 6.	Plonts germ. Nov. 8, addit.	Plants germ. Nov. 14, addit.	Total germinated, also per cent.
1	Hot water 130°F.....	5 mins.	60	14	3	77
2	" 130°F.....	5 "	11	11	71	93
3	" 130°F.....	10 "	7	28	53	88
4	" 130°F.....	10 "	62	18	12	92
5	Check, water........	10 "	64	26	9	99
6	" "	10 "	48	15	21	84
7	Copper sulfate. 1–64..	6 hrs.	83	11	3	97
8	" " 1–64..	6 "	80	16	0	96
9	" " 1–128.	6 "	87	10	1	98
10	" " 1–128.	6 "	78	17	0	95
11	Check, water........	6 "	54	21	13	88
12	" "	6 "	69	10	9	88
13	Copper sulfate 1–64..	18 "	92	7	0	99
14	" " 1–64..	18 "	69	30	0	99
15	" " 1–128.	18 "	91	6	0	97
16	" " 1–128.	18 "	82	13	3	98
17	Check, water........	18 "	84	3	1	88
18	" "	18 "	50	40	3	93

No.	Nov. 1, 100 seed treated with	Time.	Plants germ. Nov. 24.	Plants germ. Nov. 27, addit.	Plants germ. Nov. 29, addit.	Total germinated, also per cent.
19	Copper sulfate 1– 8..	6 hrs.	75	12	4	91
20	" " 1–16..	6 "	80	16	1	97
21	" " 1–24..	6 "	82	16	1	99
22	" " 1–32..	6 "	71	11	1	83
23	Check, water.......	6 "	66	27	2	95
24	Copper sulfate 1– 8..	18 "	74	25	1	100
25	" " 1–16..	18 "	52	36	1	89
26	" " 1–24..	18 "	62	35	2	99
27	" " 1–32..	18 "	61	32	5	98
28	Check, water.......	18 "	41	33	4	78

In the above experiment nos. 1–18 were germinated on moist filter paper, while with nos. 19–28 moist sand was used. The check lots were soaked for a corresponding period in water,

since soaking the seed is often resorted to in practice. In general, even the strong solutions of copper sulfate gave slightly better results than the water; and germination was often slightly hastened. In a preliminary test, the germination was very markedly in favor of the copper treated seed; but since the conditions were abnormally close and moist, the exclusion of bacteria by the copper solution might have caused the apparently excessive benefit. It remains to be determined, however, if it is desirable to treat the seed for the prevention of the leaf-spot.

62.—*Beet scab.*

III. BEET SCAB (*Oospora scabies* Thaxter).

a. Appearance of the Disease.

The smooth surface of the beet root may often be disfigured by warty or scabby excresences. The texture of these injuries is somewhat corky or spongy, and the larger diseased areas will show that the injury is not entirely superficial, but to some extent alters the tissues immediately underlying such areas. The frontispiece shows two beets affected in a characteristic manner. The disease begins as small irregularities either widely scattered or clustered. Individual ones spread in extent, and groups often become united, so that in time it may spread over large areas, or small isolated areas may remain. One often notices a tendency for the scabby spots to be arranged in more or

less definite bands, often just at the surface of the ground. The diseased bands, or areas, may, however, appear much lower, as in figure 62. It is very probable that this is determined by soil and moisture conditions. The scabby protuberances are abnormal developments of corky tissue stimulated to excessive growth by the presence of the fungus. Professor Arthur has noted sunken scabby spots on the surface of the beet, and he explains these as early injuries which failed to develop further, when the

63.—*Scabby potatoes.*

conditions were probably unfavorable, and future growth of the beet has left them rather as pits than as excrescences.

b. The Cause of the Disease and Its Prevention.

In 1890 Professor Thaxter discovered that potato scab is caused by the growth on the surface of the tuber of a fungus which he named *Oospora scabies*. When scabby potatoes, such as are represented in figure 63, are placed in a moist chamber, a light,

grayish, mould-like growth of the fungus may appear on the surface; and it was by inoculations with pure cultures of this fungus that he was able to reproduce the disease on healthy tubers. The following year Professor Bolley found the scab of beets abundantly, and the microscopic evidence which he obtained indicated that the fungus was the same in both cases. He furthermore ascertained that in all cases when the beet scab was abundant, potatoes had been grown on the soil, either the previous year or somewhat earlier. Working independently, at about the same time, Professor Arthur came to similar conclusions about the identity of these two forms of scab; and a single decisive experiment in the transfer of scab from potato to beet was reported by him. Since that time there has been abundant general evidence to establish the fact that scabby beets may be expected if the seed are sown on land which has recently produced scabby potatoes. On the College Farm during the past season it has been very significant that the land producing scabby potatoes the previous season, produced scabby beets last season, while infected soil produced beets free from the disease.

The remedy cannot consist in this instance in the treatment of the seed, since the seed do not disseminate the disease; nor can it consist in the treatment of the land, since the experiments with liming, sulfuring, etc. have not given satisfactory results. The only course open, then, is the one of avoiding for the growth of beets any soil, which, during several years previous, has produced scabby beets. B. M. DUGGAR.

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Bulletin 164. February, 1899.

Cornell University Agricultural Experiment Station,

ITHACA, N. Y.

BOTANICAL DIVISION.

PEACH LEAF-CURL

AND NOTES ON THE

Shot-Hole Effect of Peaches and Plums.

By B. M. DUGGAR.

PUBLISHED BY THE UNIVERSITY,

ITHACA, N. Y.

1899.

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CORNELL UNIVERSITY, ITHACA, N. Y., February 7, 1899.

THE HONORABLE COMMISSIONER OF AGRICULTURE,
ALBANY, N. Y.

Sir: Of the many diseases with which the fruit-grower has to contend, probably no one has been more generally prevalent during the past season than the peach leaf-curl. Wherever horticultural schools or meetings have been held, questions have come up concerning this disease and its treatment.

Moreover, the greater part of the correspondence referred to the mycologist during the spring of 1898 was in regard to the peach leaf-curl fungus and remedies for the same; fortunately, experiments relative to preventive treatment were already under way.

In this bulletin, Mr. Duggar has given a brief and clear account of the fungus causing the leaf-curl, and he has outlined a treatment which, under difficult conditions, has proved most satisfactory. The peach leaf-curl is one of the three great enemies of the peach-growing industry and like the other two, the yellows and the borer, if neglected or if treated unintelligently, the orchard soon becomes unprofitable, and finally is entirely destroyed.

I. P. ROBERTS, Director.

PEACH LEAF-CURL AND NOTES ON THE SHOT-HOLE EFFECT OF PEACHES AND PLUMS.

I. Peach Leaf-Curl.*

a. *General Remarks.*

In bulletin 73 of this Experiment Station a complete account was given of the fungi causing leaf-curl and plum-pockets on many members of the genus Prunus. In the present discussion of the leaf-curl of the peach it will be unnecessary to go into technical details; but in order, as far as possible, to have a reason for that which is done, or recommended, a general account of the life history of the fungus must be included.

Peach leaf-curl is a disease which has long been known to the orchardist as well as to the botanist; and since the seasons of 1897 and 1898, there are probably very few peach growers in the state who are unfamiliar with the disease. The inquiries received during the past spring concerning this disease were so numerous that it has seemed important to give to the growers the results of the work of a single season, along with those results which have been elsewhere obtained. Many of the inquiries have sought a remedy only, but still others have desired a knowledge of the cause; and a general treatment of the subject is necessary.

b. *Appearance of the Disease.*

Peach leaves affected with the curl can often be detected as soon as the leaf buds have opened to a slight extent. A roughened surface of the young leaf, and an excess of coloring are usually the first indications. As the young leaves rapidly assume their normal size, this curling and arching of the blades is more prominent. Sometimes there is distortion in a small area only, and again the entire blade may be affected. The curling of the edges of the leaves may be upward or downward, or the

* *Exoascus deformans* (Berk.) Fuckel.

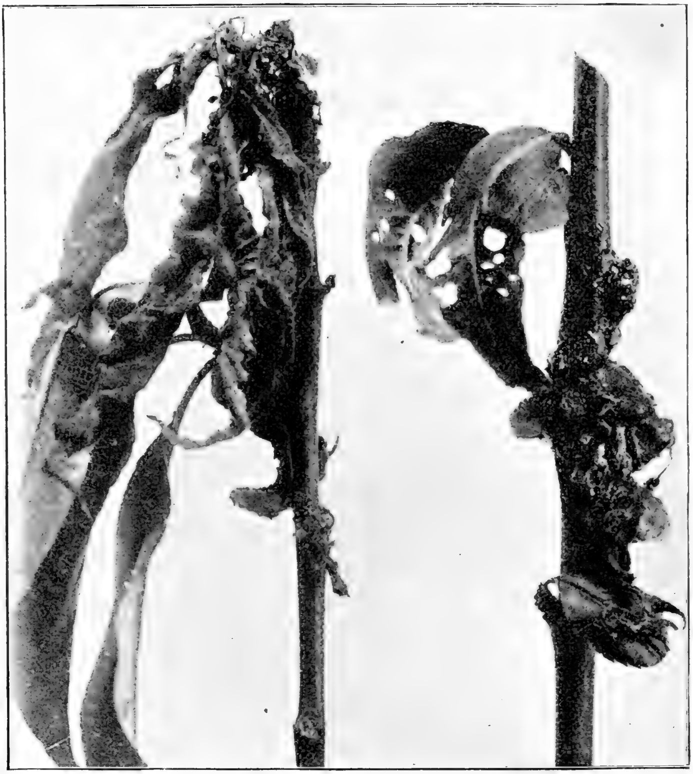
upper surface of the leaf may be gradually arched from base to tip. When the leaf is full grown, the diseased areas may be reddish green ; but usually the green color is largely lost and a pale discoloration characterizes diseased parts. The frontispiece and

64.—*A terminal shoot with both leaves and twig affected by the leaf-curl fungus.*

figure 64 show the appearance of the disease on a cluster of leaves terminating a shoot. Figure 64 also shows another point to be observed. Not only are leaf and leaf-stalk affected, but the terminal part of the shoot becomes much enlarged, and also pale in color. The fungus is then thoroughly established in

the tip of the branch, and the significance of this is apparent later on.

The leaves soon become grayish or mealy in appearance. This appearance is due to the fact that the fungus is fruiting,



65.—*Peach curl and gummosis.*

producing the spores which are to disseminate the disease. After the grayish color appears, the affected leaves gradually dry up and fall off. In this latitude the defoliation from such injuries usually occurs late in June.

In the late stages of this curl disease, as with some other peach diseases, gummy exudations are often noted on those twigs which are enlarged by the fungus; or these may occur even on

the large branches where a diseased cluster of leaves has been attached. Figure 65 shows the condition often called gummosis.

Defoliation of the entire tree does not necessarily mean the death of the tree; but it does mean the death of many twigs, and lessened vitality. New buds, or rather some of the sleeping or dormant buds open and the tree attempts to supply itself with new and healthy foliage. It is very seldom that this fresh foliage is badly affected by the curl; and it is possible to account

a *b* *c* *d*

66.—*a, healthy twig; b and c, twigs in which the leaf-curl fungus is wintering; and d, twig killed by the fungus.*

for whatever curl is now evident as having come directly from diseased buds or twigs.

The new shoot growing out from a diseased terminal bud may grow entirely out of the disease, but the swollen part remains below. Thus, when the season's growth is done and the autumn at hand, these swollen areas may mark out the recovery of shoots; but they also indicate where the fungus rests; and they are warnings of danger for another season. Figure 66, *b* and *c*,

show the appearance of twigs in which the fungus is wintering; *a*, a twig of the same age which is perfectly normal; and *d*, a twig killed by the presence of the fungus in its tip.

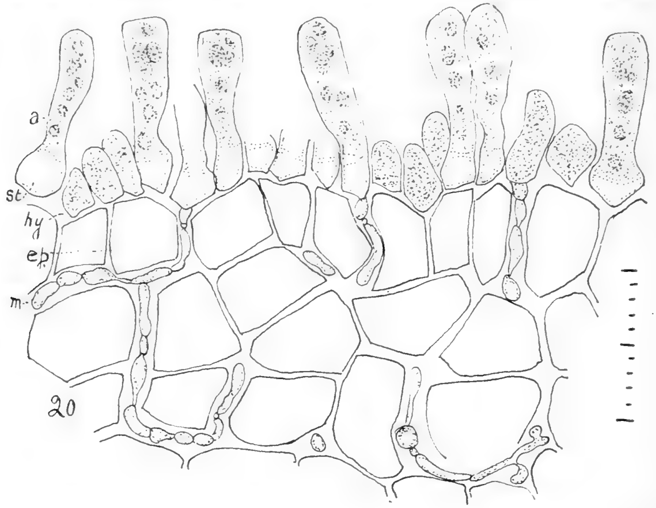
c. Life History of the Fungus.

In this latitude it is usually the latter part of May that the curl is most pronounced, and the grayish appearance is evident soon afterward on all diseased leaves, and on both surfaces of such leaves. The surface is evidently covered with a dense close growth, somewhat mould-like in character. As previously mentioned, the fungus which causes the curl is then fruiting, forming the spores which are to disseminate the disease; but this cannot be seen by the eye alone. Examining under the microscope some of the close growth scraped from the surface of diseased areas, numerous short, erect, thread-like growths (fertile hyphae) will be evident, as in figure 67. Close examination at the time that the fungus is mature shows that these erect hyphae are sac-like in appearance (the asci), and they usually contain eight oval bodies called the spores. In the asci the spores may sprout or bud, forming numerous conidia. After these spores or conidia are mature, they are soon set free from the sac-like structures; and being so minute and light, they are ready to be borne about by the wind. When they fall upon vulnerable parts of other trees, they are in readiness to grow into the tissue and to produce the disease again.

The fruit of the fungus is produced on the surface of the leaf, but the true vegetative state of the fungus is within the tissues of the leaf and of the young shoots. The threads, or filaments, which make up this vegetative state pass in between the cells of the leaf, and it is the irritation due to the presence of these fungous filaments (the mycelium) which causes the leaf to become distorted in form. Passing into the young shoot, the fungus is in a condition to pass the winter in situ, provided the twig lives, without having to trust to the fortune of winds and rains, as is the case with the spore.

It is unfortunate that the exact fate of the more fortunate spores is not known. Since the second growth of leaves is not badly infested by the curl, the spores do not produce the disease

again immediately, it seems. One of two possibilities is then open; either (1) to germinate immediately and infect the buds which will open the next season; or (2) to be hidden away about the twigs, in the bud scales, or even on the ground about the tree, and there to pass the winter, germinating the next spring. On leaf surfaces of its host plant Sadebeck* has germinated the



67.—*Cross section of a part of a leaf affected with leaf-curl, showing the fruiting of the fungus.* (*From Bulletin 73, by Professor Geo. F. Atkinson.*

spores of a closely related species growing on Alnus. This took place, apparently, soon after the spores were produced. It is hoped that some studies now under way will throw light upon this important matter,—important because treatment can be made more effective the more complete is our knowledge concerning time and method of infection. At present, the results from preventive treatments indicate that normal infections take place in the spring.

d. Conditions Affecting the Abundance of the Leaf-Curl.

The sporadic occurrence of the leaf-curl is rather remarkable. In many sections of the State there was very little in 1896. The

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* Unters. über d. Pilzgattung Exoascus, u. d. durch dieselbe um Hamburg hervorgerufen Baumkrankheiten. Abgedruck a. d. Jahrb. d. Wiss. Anst. p. 102, 1883, Hamburg.

same sections in 1897 saw a large increase in the abundance of the disease, and the past season was characterized by unusual injuries from this cause. This wave of increasing abundance during the past few years seems to have extended quite generally through the Northern States, judging from inquiries received, and from the activity of experimenters in this field of work at various experiment stations.

Attempts have been made specifically to define the conditions which encourage the curl. Some have asserted that a cool, moist spring is most conducive to its abundance. The time of infection, however, should be determined, it seems, before any satisfactory explanation may be given. It is quite reasonable to suppose that the conditions prevailing at the time the spores of the fungus are being disseminated, or the conditions prevailing at the time the spores germinate to infect the buds or leaves would be the factors to determine the greater abundance or the less abundance of the disease the following year. If the spores of the fungus live over winter on the ground or twigs, and germinate with the first warm days of spring to infect the opening buds, then the spring conditions would seem to be of great importance in determining the amount of the disease. If, however, infections result during summer or autumn the effect of spring conditions is not apparent.

It is well known that different varieties of the peach show different degrees of susceptibility to the attacks of leaf-curl. The same is often found to be true of other plants attacked by other fungous diseases, and it can only be explained by constitutional differences in the varieties. Among varieties of peaches very susceptible to the curl, Selby* mentions Mountain Rose, Old Mixon, Globe, Elberta, Scott's Nonpareil, Red Cheek, and others. Such a list will, in all probability, vary with the place, and I have examined some orchards of many varieties in which none were exempt.

e. Remedies.

The early experiments made to determine the value of fungicides for the prevention of peach curl were unsatisfactory both

*Bulletin 92, Ohio Agricultural Exp. Station, 1898.

68.—*Photograph showing rows 2 and 3; row 2, on the right, sprayed early with Bordeaux mixture; row 3, on the left, sprayed late with Bordeaux.*

because the fungicides themselves often injured the leaves, and also because the best time for spraying was not apparent from our knowledge of the fungus. Much of the later work has been to demonstrate that spraying one season lessons the disease during the succeeding season. At the time that my experiments were begun, I was not aware of other results.

In an orchard of young trees closely set and used for some experiments with borers, by M. V. Slingerland, leaf-curl appeared in 1896. The following year it was so abundant as to cause almost entire defoliation, and there was every promise of an abundant reappearance of the disease in 1898. These trees were so close together that they were especially desirable for such work, since it would be very probable that any remedy proving more or less effective under such conditions would be even more effective under ordinary circumstances. There was also the additional advantage that the trees were all known to have been affected the previous year. Several varieties were represented in the orchard, and the experimental rows were run across varieties, so as to eliminate any error on this score.

The treatments given, and dates of spraying, were as follows :*

Row 1. Check.

2. Bordeaux mixture, April 8, May 10, May 21, June 8.

3. Bordeaux mixture, May 10, May 21, June 8.

4. Bordeaux mixture, April 8, Potassium sulfide, May 10, May 21, June 8.

5. Check.

6. Potassium sulfide, May 10, May 21, June 8.

7. Bordeaux mixture, April 8, Ammon. copper carbonate, May 10, May 21, June 8.

8. Ammon. copper carbonate, May 10, 21, June 8.

In the statement of results the abundance of the disease the previous year must be remembered, for it is very evident that no hope could be entertained for securing exemption from the disease where the fungus had been carried over winter in the twigs.

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* In this experimental work Mr. H. P. Gould coöperated with me.

Notes on the results at the different dates may be stated thus:

Apr. 8.—Buds hardly beginning to swell. (1st spraying.)

May 10.—Soon after pollination of the flowers; petals dropping, and young leaves out from one-half to one inch long. Even at this time a large number show that the curl is present, by increased reddish coloration, but almost no distortion of surface. Microscopic examination showed that there was yet no fruiting of the fungus. (2d spraying.)

May 21.—Curl showing abundantly in the orchard both on leaves and twigs; fungus not yet fruiting. (3d spraying.)

June 1.—Row 1, (check). Very bad; almost every leaf on the tree affected.

Row 2, (Bordeaux early). Very good, curl mostly confined to some of the tips of growing twigs.

Row 3, (Bordeaux late). Very bad; almost every leaf affected.

Row 4, (Bordeaux early, Potas. sulf. late). Very good; perhaps slightly more curl than in row 2.

Row 5, (Check). Very bad; almost every leaf affected.

Row 6, (Potas. sulf. late). Very bad; a large majority of the leaves affected.

Row 7, (Bordeaux early, Am. cu. carb. late). Very good; almost equal to No. 2.

Row 8, (Am. copper carb. late). Very bad; almost every leaf affected.

Particular attention should here be directed to the fact that where Bordeaux mixture was used before the buds swelled, the foliage of the trees was very largely entirely free from the curl, even during this first year of treatment; and this was true irrespective of the mixture subsequently used (compare rows 2, 4, and 7). Unfortunately there was no row which received the first treatment only.

June 8.—On this date, the time of the last application, the leaves badly affected were falling abundantly. Soon after this time the photograph was taken from which figure 68 is reproduced. This figure shows the difference between the row sprayed late with Bordeaux, and the row sprayed both early and late with Bordeaux, rows 2 and 3.

The final results indicate very significantly that at most there is very slight effect from the treatments subsequent to the early treatment with Bordeaux, and that the early treatment is the one of importance for the protection of the foliage during the same year. Perhaps the subsequent treatments may prove of value as to the amount of the curl the following year, and this is what others have already demonstrated.

69.—*A branch from a tree in row 2, sprayed early with Bordeaux mixture.*

Since securing these results, I have had correspondence with some orchardists who had sprayed peach trees for various diseases. With few exceptions, those who have sprayed early have been those successful in the prevention of the curl.

A very interesting result has been reported by Mr. A. I. Loop of North East Penn. So far as the prevention of curl is concerned, the benefit was accidental; but the value of early spraying is again demonstrated. From his letter, I quote as follows, "The experiment was to try the effect of whitening for the protection of buds during winter. The directions given by Professor Whitten in his bulletin issued at Columbia, Mo., were followed. A selection was made about the center of a block of 4000 trees; about a dozen trees across the rows, including different varieties, were treated. The first application was made

the first week in January, using his regular milk and lime formula. The next was the same treatment on the first of February. They were again treated about the first of March, but instead of milk we used dextrine. * * * As to results,—we could discover no difference in time of blossoming between the treated and untreated trees. * * * We discovered one thing, however, that we thought remarkable. All of our trees were considerably affected with curl-leaf, but we found these treated trees to be almost absolutely free from it. At least one-half of these trees have not shown a single diseased leaf up to the present time (July 27); about one-half of them had one or two diseased leaves. The adjoining trees on both sides and on each end of the treated trees without exception showed many curled leaves, from 25 per cent to 75 per cent of all of the leaves on the trees being affected."

The above is very conclusive, even with a fungicide, dilute whitewash, which we have not held in high esteem when used alone. For this early treatment it has one of the special advantages of Bordeaux mixture, that of adhering well.

In the Year Book of the U. S. Dept. of Agriculture, 1897, page 110, there are given some noteworthy figures concerning the gains which growers on the Pacific coast have enjoyed by following out certain lines of treatment suggested by the Department. This report was not out until our experiments were practically complete, and in it no statement is made of the time when the applications were made. I have since learned, however, that special stress is laid upon the early spraying. The results at other experiment stations, notably at Ohio, largely confirm what has already been said concerning remedies.

Special recommendations:—With our present knowledge of peach leaf-curl, the following may be suggested:

1st. Spray thoroughly with strong Bordeaux mixture just previous to the swelling of the buds, late in March, or very early in April seems desirable in this latitude.

2d. Spray again with weaker Bordeaux as soon as the petals of the flower have fallen, or after the work of the bees is over.

3d. Spray again with weak Bordeaux when the first leaves are just full grown, or at just about the time that the spores of the fungus are developing.

Discussion of recommendations :

1st. Why not spray in midwinter ? Midwinter spraying may be quite effective, but there is every reason to believe that the April spraying will be better ; for if that is near the time that the buds are infected, the spores will then be more readily killed. If a time when other work is not pressing is of first importance, spray earlier. Why not use copper sulfate solution? It may be quite as efficient, but Bordeaux adheres better and would be more likely to prevent infections throughout a period.

2d. Why? Late infections by spores from the ground or from neighboring fields may thus be guarded against.

3d. This spraying is to cover the leaves with Bordeaux at about the time the fungus is fruiting, hoping not only to prevent summer infections, but to cover places where the spores may lodge in order to pass the winter.

70.—*A branch from a tree in row 3 sprayed late with Bordeaux mixture.*

The Bordeaux Mixture.

In making the first spraying, the all-important one, strong Bordeaux mixture may be used ; and every twig should be so well covered that the blue color appears as a distinct coating after

the application has dried. However, under certain conditions, the foliage of the peach seems to be easily injured by spraying with Bordeaux mixture. With weak Bordeaux mixture properly made, I have not been able to produce any injury on the trees experimented upon.

The customary formula for Bordeaux mixture is :

Copper sulfate (blue vitriol)	6 lbs.
Unslaked lime (good quality)	4 lbs.
Water	50 gallons.

In spraying the foliage of peach trees, reduce the copper sulfate to four pounds. Even this may seem strong. It should not, however, be condemned until tried; and when tried the mixture should be made by the one method which has been most successful.* To dissolve the copper sulfate, suspend it in a coarse sack in a barrel containing twenty-five gallons of water. Slack the lime (use only the best) slowly, and then dilute it to twenty-five gallons. Pour the two together in this dilute form, stirring for a few minutes. Stir before using. If large quantities of the mixture are desired, stock solutions may be made as usual. Dissolve say fifty pounds of the copper sulfate in a barrel containing as many gallons of water. The stock solution of lime may be made of the same strength. Then each gallon means a pound of the substance wanted. When the mixture is made, dilute each solution separately before pouring them together.

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* See *Farmers' Bulletin* No. 38, U. S. Dept. Agriculture, p. 6.

II. NOTES ON THE SHOT-HOLE EFFECT OF PEACHES AND PLUMS.*

During several years past I have received from a few correspondents, leaves of the plum and of the peach badly affected

71—*Shot-hole effect on Japan plum sprayed with improperly made Bordeaux mixture.*

with a shot-hole injury. The interesting feature of the cases mentioned was the fact that this injury occurred where the trees

*Fuller details upon this subject will be found under the same title in the Proceedings of the Soc. for Promotion of Agl. Sci., 1898.

had been abundantly sprayed. From observations already made, I had suspected that other causes besides the shot-hole fungus might be responsible for some of the troubles referred to me. In one case, especially, there was an unusual appearance of the shot-hole effect in a large orchard soon after the application of Bordeaux mixture.

On the horticultural grounds of the Experiment Station, during the season of '97, Mr. H. P. Gould called my attention to the abundance of the shot-hole effect on Japan plums which he had sprayed constantly. I had then completed some experiments with the production of such injuries by means of substances injurious to the foliage; and the results indicated clearly that injuries to the foliage by many deleterious chemical agents might produce the characteristic shot-hole appearance.

It was reasonable to believe that spraying might have the same effect under certain conditions. Later experiments were made to test the effect of some copper compounds upon the foliage of the peach and of the apricot, and comparatively upon plums of the native, domestica, and Japan groups. In general the peaches, apricots, and plums of the native and domestica groups were free from any shot-hole effect; but the Japan plums generally indicated some injuries of this kind. The entire orchard had been sprayed with Bordeaux mixture tested with potassium ferrocyanide. A few trees of each kind mentioned were then sprayed with properly prepared Bordeaux mixture, with Bordeaux mixture containing an excess of copper, with Bordeaux made by the use of poor lime, and with a solution of copper sulfate containing one pound of the compound to about 15 gallons of water.

The properly prepared Bordeaux produced no injury except upon the Japan plum (Burbank); but there was an evident injury in the latter case. The improperly made Bordeaux mixtures affected the peach and the Japan plum to a marked extent, a photograph of injuries to the latter being shown in figure 71. By the same mixture the apricot and the native plum (Yellow Transparent) were somewhat injured, while the effect upon the domestica (Empire) was scarcely noticeable. The copper sulfate solution of course produced injury in all cases, but this injury was very little in the case of the domestica, and somewhat more pro-

nounced with the native. On the Japan plum and on the apricot a marked shot-hole effect was produced, followed by considerable

72.—*Shot-hole effect on peach produced by weather conditions.*

defoliation, and on the peach there was complete defoliation within a few days.

The shot-hole effect abundant among Japan plums in the orchard was again examined, but there was no indication of a causal fungus; and very significant was the fact that young

shoots growing out beyond the region covered by the spraying were wholly free from such injuries. There was no doubt that this general appearance of a shot-hole fungus on the Japan plums was due directly to the spraying. An unsprayed orchard of Burbank and Abundance in the vicinity showed no shot-hole injury whatever.

Later experiments on the Chabot plum confirmed the previous work, indicating that under certain conditions the Bordeaux mixture may be injurious to the foliage of the Japan plums, much more so, in fact, than to that of the peach.

Among the varieties which have shown the greatest injury from spraying during the past season may be mentioned, Willard, Chabot, Douglass, Berckmans, Earliest of All, Georgeson, Ogon Kelsey, Blood No. 3, and Abundance. Burbank and Red June were also affected. Forest Garden was the only native plum noticeably affected, and all varieties of the domestica group were conspicuously free from the trouble.

An examination of specimens of the various fungi affecting the peach and the plum will show that, with the exception of leaf-curl, mildew, and a few others, these fungi are very generally productive of a shot-hole effect. The fungus most abundant in a particular region will be the one there designated as a shot-hole fungus. With these facts at hand, my experiments with fungicides and other chemical agents above referred to were made. These results are sufficient to demonstrate that this shot-hole effect is a peculiar physiological reaction of the plant to injuries of many kinds.

Figure 72 shows an effect of this kind produced by peculiar causes. The tree was blown down during a summer rain storm. The rain was followed by a hot, steaming afternoon; and in about two days the shot-hole effect was evident.

After an examination of a number of plum orchards in this State, I find the Japan plums so free from shot-hole fungi that I see no necessity of spraying them for these particular diseases and thus encouraging a shot-hole effect due to spraying.

Where the plum rot is bad, it will be necessary to spray, and one must disregard the slight injuries to the foliage resulting from the use of properly made Bordeaux mixture.

B. M. DUGGAR.

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Bulletin 165. March, 1899.

Cornell University Agricultural Experiment Station.

ITHACA, N. Y.

DAIRY DIVISION.

Ropiness in Milk and Cream.

By ARCHIBALD R. WARD.

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ITHACA, N. Y.
1899.

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THE HONORABLE COMMISSIONER OF AGRICULTURE,

ALBANY, N. Y.

Sir: This bulletin is submitted for publication under Chapter 67 of the Laws of 1898.

The abnormally viscid condition of milk and cream, commonly designated "ropy," is familiar to many dairymen, and its occurrence causes most serious loss.

This publication contains a brief résumé of the conclusions reached by earlier investigators together with a detailed account of the investigations carried on by the College of Agriculture. The conclusions reached in this publication, based upon actual experience and supported by those of other investigators, indicate that this trouble may be arrested or prevented by the exercise of precautionary measures intelligently directed.

Further, it has been found that ropiness in milk is a trouble which may be transmitted by the unclean milk utensils of the dealer or by those of the consumer. Because of this fact, certain dealers have been unjustly accused of delivering faulty milk, when the true cause was the unclean milk utensils used by the consumer. Therefore the information conveyed by this bulletin is of interest to those dealers who, although exempt from this trouble, are anxious to preserve a good name, as well as to those suffering losses as a result of faulty methods.

I. P. ROBERTS, Director.

DESCRIPTION OF PLATE.

1. *Bacillus lactis viscosus* from an agar slant culture eight days old, stained with carbol fuchsin. × 1,000. A loopful of the viscid growth was drawn across the cover-glass. The linear arrangement of the organisms probably is due to the capsules.

2. *Bacillus lactis viscosus* from a bouillon culture three days old, stained with carbol fuchsin. × 1,000. This preparation shows the extreme variation in size and the polar stain exhibited by this organism when grown in bouillion.

3. Drawing from a cover-glass preparation from a milk culture of *Bacillus lactis viscosus* twenty-four days old, stained with carbol fuchsin. × 1,000. The presence of a capsule is indicated by the unstained areas surrounding the organisms.

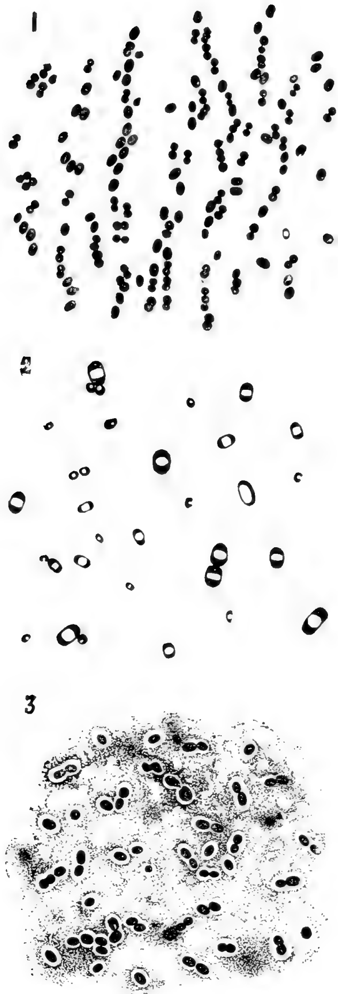

PLATE IV.—*Bacillus lactis viscosus.*

ROPINESS IN MILK AND CREAM.

BY ARCHIBALD R. WARD.

Ropiness in milk is one of the most serious troubles with which milk dealers have to contend. This condition which is objectionable more on account of its unwholesome appearance than from any known harmful effect which it produces, has received its popular designation from the viscid, slimy, consistency which characterizes the affected milk. The cause has been found to be the action of certain bacteria, and a number of apparently different species have been described as possessing the power of producing the ropy condition. Among those who have written on this subject should be mentioned Adametz, Loeffler, Guillebeau and Marshall. Nevertheless, few definite determinations have been made concerning the natural habitat of these particular species of bacteria and the channels through which they gain entrance to the milk. Further information on these points is especially desired in order to successfully combat the trouble and to prevent its recurrence.

This trouble which is wide spread and of considerable economic importance to milk dealers and butter makers, should not be confused with the abnormal changes in milk which accompany an inflamed condition of the udder frequently called "garget." Milk drawn from udders in this condition is more or less thickened by the presence of pus or may in addition contain white, tough, solid masses of casein which pass through the duct of the teat with more or less difficulty. Milk in such condition is by some called ropy and consequently it has been asserted that a diseased condition of the udder is the cause of all ropy milk. The investigations which have heretofore been made do not throw any definite light upon this alleged cause. They do not suggest a necessary dependence upon a diseased condition of the udder, although they do not preclude the possibility of such a combination. The fact that each of the authors referred to was able to isolate a species of bacteria capable of producing this trouble under artificial conditions, suggests that its source is very likely

without, rather than within the udder as suggested by the "garget theory." Von Freudenreich isolated a gas producing bacillus* from the udder of a cow which was suffering from mammitis. In addition to establishing its etiological relation to the diseased condition of the gland, Guillebeau, who studied the organism isolated by von Freudenreich, found the bacillus to produce viscosity in milk. As this organism has not been reported by others as causing ropiness in milk and as it is associated with mammitis, in which case the milk is of no commercial value, it is of little significance when considered as a cause of ropy milk.

Adametz† has shown that *Bacillus lactis viscosus* possesses a slimy viscid capsule which envelops each organism and by reason of this is enabled to bring about a corresponding condition in milk when the individuals are present in sufficient numbers. In the year following the discovery of this bacillus in brook water, Adametz again isolated it from a sample of milk obtained from a dairy in which trouble from ropy milk was experienced intermittently. Although not verified by bacteriologic examination, the indirect cause of each separate outbreak was believed to be the occasional use of water from a certain well. It was observed that trouble was experienced upon each occasion when because of drought it became necessary to use the water of this well, and immunity from trouble was attained by avoiding the use of the water in question.

Mention of this bacillus described by Adametz is to be found in several works upon bacteriology. In each reference a statement is made to the effect that the viscid change caused by *Bacillus lactis viscosus* takes place so slowly at room temperature that it can not be the cause of ropiness under ordinary conditions and that Adametz's painstaking investigations are only of a

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* Landwirthschaftliches Jahrbuch der Schweiz, 1890, p. 41.

† Landwirthschaftliche Jahrbücher, 1891, p. 185. Earlier and less complete reference to this organism are to be found in the Milch Zeitung, 1889, No. 48, p. 941, abstracted in Centbl. für Bakt. und Par. Bd. VII, 1890, p. 767. Also in the Oesterreichische Monatsschrift für Thierheilkunde und Thierzucht, Jahrg XV. 1890. No. 2, p. I, abstracted in Centbl. für Bakt. und Par. Bd. VIII. 1890, p. 109.

theoretical interest. After a critical reading of Adametz's paper in the *Landwirthschaftliches Jahrbücher* of 1891, it becomes evident that misconstructions have been placed upon his statements. On page 191 of the volume referred to he makes a statement of which the following is a translation: "Sterile milk inoculated with *Bacillus lactis viscosus* and kept at room temperature, shows lit tle outward appearance of change during the first two days But the surface layer of cream is found to be ropy when tested and the increased viscosity of the skim milk below becomes evident when it is stirred." Farther on in this paper he says: "In cultures contained in test tubes where the milk is slightly exposed to the air,* the complete change of all the milk does not occur until about four weeks." Those writers who have underestimated the practical bearing of Adametz's work, seem to have labored under the impression that ropiness must necessarily appear in the depths of the milk as well as in the cream, in order to be the cause of serious trouble.

My observations upon the occurrence of ropiness in milk in creameries in New York, and the identification of *Bacillus lactis viscosus* as the cause, show that the ropiness brought about by that organism although appearing only in the surface layer of milk, may become of considerable commercial importance.

In the summer of 1898, the appearance of ropy milk in a locality near Ithaca was brought to notice by a milk dealer, who, having suffered severely in loss of custom by its occurrence, applied to the College of Agriculture for aid. He was instructed to dampen the udders of the cows with dilute carbolic acid before each milking. This measure, which is of value in preventing filth on the udder from falling into the milk, was carried out faithfully without benefit. With the view of ascertaining facts which would lead to methods of prevention, a careful study was made of the conditions under which the outbreak occurred.

The attending conditions were as follows: All of the milk handled by this dealer was supplied by one dairy consisting of twelve cows. The surplus of milk over that disposed of on the

* The fact that *Bacillus lactis viscosus* is an obligate aerobe explains the behavior in milk observed by Adametz.

route was used for butter making, the deep setting system of creaming being used. The cream on the surface of the cans of milk which stood in water at a temperature of from 45° to 50° F. (7°–10° C.) became viscid in from twenty-four to forty-eight hours after setting, so that it would adhere to a table fork, stringing out in a ropy mass. The frontispiece of this bulletin illustrates the typical behavior of the cream. The viscosity was more marked in the surface layer of the milk, and hence in the cream. It is for this reason that the trouble is incorrectly regarded as a fault peculiar to cream. No complaint was heard from those customers who consumed the milk within a few hours. Some of them, however, kept the milk until the following morning when the cream would be ropy.

A bacteriologic examination of the ropy cream revealed the presence of *Bacillus lactis viscosus*. After isolating from the viscid cream an organism which invariably produced the ropiness in milk (or cream) when inoculated with it, further work to determine the distribution of this organism in nature and to find out through what channels the milk became infected seemed highly desirable. To accomplish this it was proposed to collect samples of the milk at each step in the processes to which it was subjected between the cows' udders and the deep setting cans where the ropiness becomes manifest. The fact that the organism grows in milk at a temperature of 54°F. (12°C.) and produces ropiness in a few days, was a valuable aid in the search since such a low temperature will prevent the rapid multiplication of most species of bacteria in milk. If the samples collected are kept at room temperature, there is no assurance that *Bacillus lactis viscosus* can be detected among the other bacteria present. By lowering the temperature the growth of most microörganisms is checked, without seriously hindering the multiplication of the one causing the ropiness. It was just this condition in the creamery which enabled that species to assert its presence in the deep setting cans.

In taking samples of milk from each cow, the udders and teats were moistened with a weak solution of carbolic acid, this being the only safeguard taken to prevent the access of dust. Glass milk bottles were scalded and kept sealed with paper covers,

except at the moment the samples were drawn. The wide mouth of the bottle offered considerable opportunity for the entrance of dust particles which might convey the bacteria had the particular species in question been adhering to the udder. The twelve samples were kept cool but none became viscid.

All other samples were drawn into test tubes the mouths of which presented a smaller area for the reception of dust. The tubes had been previously plugged with cotton and heated, rendering them absolutely sterile. At one milking period two samples were taken from each cow. One was from the first milk drawn and the other from the strippings. Two more samples were taken from each cow on different days. In every case they were kept at a temperature of about 12° C., none of them becoming viscid.

Cultures were made from the milk of each one of the cows on two different days, the bacteria present in the milk of each cow being thus obtained in pure culture. From the first twelve samples, there were obtained five apparently different species none of which when grown in sterile milk brought about the viscid condition. None of the species at all resembled the organism sought. In like manner a second series of cultures was made from the milk of each of the cows with similar negative results. During the period that the cultures were being made from the milk, the ropy milk was constantly present in the creamery. The evidence from these experiments leads to the conclusion that the various species of bacteria which are always found in freshly drawn milk did not, at that particular time at least, contain among them the species capable of rendering the milk viscid. *Bacillus lactis viscosus* itself furnishes evidence in support of the conclusion that its natural habitat is not the ducts of the udder as is true of many of the bacteria found in freshly drawn milk. This microörganism does not grow so luxuriantly at the temperature of the cow's body, 37.5° C., approximately, as it does at a lower temperature. Such would probably not be the case if the organism were accustomed to living in the udder.

In addition to examining the milk samples collected, a bacteriologic examination was also made of those substances which might harbor the obnoxious organism such as stable dust, par-

ticularly that dislodged from the udder, unclean utensils and fæces. For study of the species present in the air of the stable, Petri dishes* containing a layer of nutrient agar were used. The agar surface of each was exposed to the air for a definite length of time. The bacteria in the air, thus coming in contact with the agar, would later manifest their presence by the colonies formed as a result of their rapid multiplication upon this medium. One Petri dish was exposed under the udder of each cow at some time during the period of milking, the cover of each being off for a period varying from one-fourth to one-half minute. After four or five days at a low temperature a slight growth was observed. Had *Bacillus lactis viscosus* been present, its growth would have been visible much sooner. The several species which did grow on the agar at that low temperature were quite unlike the one sought. Sterile milk was inoculated with bits of rubbish from the floor of the stable, dust from the beams overhead, cow hair, water from the drinking trough, and sawdust from the ice house. None of the samples of sterile milk thus artificially contaminated became ropy, although all underwent some sort of fermentation. Cultures were made from the fæces of a cow, but the bacteria found threw no light upon the problem.

An examination of all of the other probable sources from which the bacteria might have gained entrance to the milk having revealed nothing, attention was turned to the utensils with which the milk came in contact. It would be a very simple matter for a milk vessel which had once contained ropy milk and which had not afterward been properly cleansed, to again infect normal milk placed in it.

Upon one occasion the milk ærator in use at the farm barn was found in an unclean condition, it having been carelessly rinsed when last used. Cultures were made directly from the milk remaining in the apparatus. Several small quantities of sterile milk were exposed to infection in the pails used for milking and also by pouring through the mesh of the strainer pail. Inoculations were made directly to culture media from the accumulated mass of filth on the border of the brass strainer. Such

*A Petri dish is a flat, shallow, circular glass vessel with sides perpendicular to the base and provided with a closely fitting cover of the same shape.

an accumulation, although innocent in appearance, is nevertheless, teeming with bacteria which infect the milk which passes through the strainer. None of the cultures made from the accumulated filth revealed the presence of the bacteria causing ropiness, nor did any of the milk samples become viscid. It was noted, however, that the bacteria found in the filth of the ærator were identical with those found growing in the milk which had been poured over it; also that those in cultures from the filthy strainer were the same as those found in the milk poured through it. These facts are of interest as illustrating how directly filth may influence the keeping qualities of milk by introducing bacteria. It should also be noted that the filth itself cannot cause ropiness in milk, unless there are present in it the bacteria which possess that power.

A bit of the cloth strainer used over the top of milk cans was placed in sterile milk. Samples of the mixed milk of the dairy were collected from the milk pails, after passing through the strainer pail, after passing through the ærator and through the cloth strainer into the milk can. All of the samples were kept cool, the various fermentations going on slowly, giving opportunity for the development of ropiness. None of the samples became viscid. From this fact it was concluded that the milk did not contain *Bacillus lactis viscosus* when drawn from the udder, nor did it gain access to the milk during any of the processes to which the milk was subjected up to the time that it was taken from the barn.

It is important now to note the results obtained from a similar treatment of the milk in the creamery. The evening's milk was brought to the creamery and placed for the night in deep setting cans surrounded by ice-water. That of the morning was ærated and brought to the creamery where it was again strained before delivering. A brass wire strainer was used constantly because it was of such size as to fit over the top of the cans, forming a convenient device for holding a cloth strainer in place. For this reason all of the milk passed through the one strainer and always into deep setting cans. The milk strained in the evening remained in the cans over night. The meshes of the strainer were seriously obstructed by an accumulation of filth, the result

of a lack of thorough cleaning. They had become obstructed to such an extent that the reservoir would become half full of milk before the pressure of the accumulated fluid was sufficient to force its way through the meshes. The deep setting cans were apparently clean but they were never placed where sunlight could act upon them.

The method employed in washing the tinware was closely observed. The tub of hot water in which the work was done, was, at the beginning, as hot as could be borne by the hand, but was allowed to cool so that it frequently fell to 80°F. (28°C.). After washing, the utensils were rinsed in hot water, but they were not subjected to a high temperature for a long enough time to sterilize them. So little importance was placed upon the necessity for extreme care in washing and scalding, that the woman who came daily to do merely that work, had been kept in ignorance of the occurrence of ropiness in the creamery.

Three different quantities of sterile milk were successively exposed to contamination on the surface of the strainer. Four other samples were allowed to remain for short periods in contact with the interior of the deep setting cans. All three samples contaminated from the strainer, and two from the deep setting cans became viscid. To insure that no mistake had been made, and that the viscid condition was caused by *Bacillus lactis viscosus*, the presence of that organism in each of the viscid samples was demonstrated by a bacteriologic examination.

The evidence concerning the cause of the constant ropiness of the milk at that time requires little comment. To recapitulate: The strainer through which all the milk passed was found upon two different days to possess the power of contaminating milk with the specific organism which causes ropiness. Two out of four deep setting cans examined were found in a like condition. During the time that the ropiness was occurring at the creamery, samples collected from the milk before being brought there did not become viscid. In addition, a bacteriologic examination of the probable sources of contamination at the farm gave negative results.

It may be suggested, and reasonably, that each of the sterile samples contaminated in the creamery may have received the

bacteria from the air rather than from the cans. There are two reasons, for considering this improbable.

First. If the bacteria had been present in the air, and were in that manner contaminating the milk, all of the samples exposed in the vessels, and incidentally to the air, should have become viscid.

Second. The bacterium which accidentally survived the cleansing process in the utensils is the one more likely to occur under the uncleanly conditions prevailing in the particular creamery visited.

Another establishment which had suffered to a similar extent from the occurrence of ropiness was visited for the purpose of obtaining additional information. The business was conducted in a manner similar to the first except that several dairies instead of one supplied the milk. At a time when the writer was not present, the proprietor of the establishment set samples of the milk of each patron noting those which became ropy. Upon this evidence, he reported several dairies as furnishing ropy milk. In one of those so reported, experiments were made of a similar nature to those in the first case, as follows: Samples of the milk of each of the twenty-eight cows were drawn into sterile test tubes, with no precautions against the access of dust from the udder. None of the samples became viscid, although they were kept in a refrigerator for ten days. Agar plates were exposed under ten of the cows, but no growth resembling that of *Bacillus lactis viscosus* appeared. Samples of the mixed milk were collected from the milk pails, before and after flowing through the strainer pail and from that which had passed through the strainer cloth, but none became ropy.

In the creamery, the cans, etc., were rinsed with sterile milk exactly as had been done at the first establishment. Two deep setting cans, the strainer and several dippers were examined. Four of the separate quantities of contaminated milk became ropy. Two of them had been contaminated in the two deep setting cans and two in forty quart cans used on the route in delivering the dip milk. Cultures of the organism in question were obtained from all of the viscid samples except one, from a forty quart can. The milk rinsed in the dippers and that poured

through the strainer did not become ropy. A quantity of sterile milk was inoculated with some of the water in use in the creamery, but the resulting changes did not indicate the presence of *Bacillus lactis viscosus* in the water. Had the results of Adametz's investigations been known to the writer at this time, a more extended examination would have been made of the water supply in both creameries.

The study of the conditions prevailing in the two creameries and the two dairies, indicated that a more thorough scalding of utensils would afford relief. It was suggested that the smaller utensils be totally immersed in boiling water for three minutes and that the larger cans be filled to the brim with boiling water for a like length of time. The suggestion was adopted and immediately brought the trouble to an end.

There were certain features connected with the outbreak which cast about it a shadow of mystery and discouraged efforts to locate the source. The two dealers consulted had purchased milk from all of the available dairies in the vicinity in an effort to supply the customers with faultless milk. Their lack of success is not surprising considering that the milk was dealt out from infected cans. From the standpoint of the consumer, the apparent wide distribution of the fault among the several dealers of the community was discouraging. A repetition of the occurrence of ropiness in milk obtained from any one dealer, generally caused the customer to patronize a rival dealer. Very frequently the change failed to prevent a recurrence of the trouble in the customer's milk vessel. Once infected, the milk pail or cream pitcher may harbor *Bacillus lactis viscosus* indefinitely, since thorough scalding is not a prominent feature in kitchen dish washing. Undoubtedly in this and in many other cases of a similar nature the consumer has unintentionally wrought great injustice upon innocent dealers by too hastily condemning the milk furnished when the true cause was careless dish washing. The importance of scalding vessels which have once contained ropy milk or cream cannot be too strongly emphasized.

The source from which *Bacillus lactis viscosus* originally reached the milk cans in the outbreaks studied is not known. Adametz has shown that its natural habitat in Austria is water. Assum-

ing that the same is true in America, there is every reason to believe that ropiness in milk caused by *Bacillus lactis viscosus* can be prevented. Whether these particular bacteria are conveyed from brook water to the milk through the agency of the cows' udders, or directly to the milk utensils by the water used in washing them, proper precautions should prevent trouble from those sources. Where the trouble occurs, particular care should be taken to avoid the use of unboiled water for cleaning utensils and to prevent the cows from wading in water.

It seems highly probable that ropiness would not appear in milk handled in *sterile utensils* and consumed within 24 hours. The evidence at hand indicates that ropiness becomes troublesome in establishments handling milk, only when it is allowed to stand for some time, as in butter making. Milk, when drawn with ordinary precautions, contains a considerable number of species and among them may occasionally be found the one in question or others capable of producing ropiness. The low temperature at which milk is kept in the deep setting process of creaming is unfavorable to the multiplication of most of the bacteria commonly present in milk, but does not entirely check the growth of *Bacillus lactis viscosus.* Owing to the unusual faculty of growing at a low temperature, that bacillus, or any other possessing that faculty, might readily come to predominate even when originally introduced in small numbers. The imperfect cleansing of infected cans, together with their indiscriminate use for containing the market milk and the cream, results in the spread of the infection through all of the utensils in the establishment and to those of the consumer as well. In creameries where butter is made and milk is also sold, exceedingly great care must be taken in scalding utensils used for creaming.

In an outbreak of ropy milk in Michigan, Marshall concluded that the bacteria* fell into the milk from the udder during milking. Unfortunately the organism described by Marshall cannot be positively identified from the brief description available but there is reason to suspect its identity with *Bacillus lactis viscosus.* The results of Marshall's investigations indicate that

* Bulletin No. 140, Michigan State Agricultural College Experiment Station.

extreme care in milking is of especial importance in preventing trouble from ropy milk. A discusssion of the general precautions which should always be taken to prevent the contamination of milk by bacteria cannot be given here, nor is it necessary. For definite instructions concerning general precautions to be taken in the stable, irrespective of the presence of trouble, the reader is advised to read a bulletin† on the care of milk which will be mailed free on application to the Secretary of Agriculture at Washington.

When it is desired to determine which of several dairies supplying a creamery is furnishing the faulty milk, it may be a valuable aid to set samples of the milk of each dairy in separate vessels and note the subsequent changes, but in order that such a test may give reliable information and the conclusions work no injustice, several precautions must be observed.

1. The vessel used to contain the samples should be provided with a cover of some sort. Either a small fruit can or a bottle is convenient.

2. Both the can and cover must be thoroughly sterilized by steam or hot water and kept covered to exclude dust except when the contents are examined.

3. The sample must be poured directly from the patron's can without coming in contact with any other vessels whatever.

4. A fine wire with a loop bent at one end is the most convenient instrument to introduce into the vessel when determining the viscidness of the cream, but the loop must be heated to redness in a flame each time before it is used. The last precaution, one of the most important, is necessary in order to prevent transferring ropy milk from one vessel to another should it be present in any.

SUMMARY.

Ropiness is a fault of milk which does not necessarily depend for its cause upon the health of the cows. It is said to be caused by any one of several different species of bacteria. I have found *Bacillus lactis viscosus* to be the cause of viscid milk in

†Care of Milk on the Farm, by R. A. Pearson. Farmers' Bulletin No. 63, U. S. Department of Agriculture.

two different creameries. In the two outbreaks investigated, the trouble was found to be caused by the use of milk utensils which had not been sufficiently scalded. The bacteria, remaining in cans which had previously contained viscid milk, were able to survive the washing and remain alive to infect new quantities of milk. Greater care in scalding utensils brought the trouble to an end. All small utensils were immersed in boiling water for three minutes and the larger cans were filled to the brim with scalding water which was allowed to remain for the same length of time. A thorough investigation of the sources from which the bacteria might have entered the milk at the stables and of sources elsewhere, failed to reveal the presence of *Bacillus lactis viscosus*. Nevertheless, from the work of Adametz, there is reason to suspect that during warm weather these particular bacteria get into the milk from water.

The importance of thorough scalding of vessels which have once contained ropy milk is urged upon the consumer as well as the dealer. Bacteria may readily be transferred from running water to milk by the agency of mud, which drying upon the udder, may be dislodged during milking. Milk utensils which have been used for containing water, should be scalded before using again for milk. The apparent purity of water used about a creamery gives no assurance that it is free from bacteria.

DESCRIPTION OF A BACILLUS PROBABLY IDENTICAL WITH *Bacillus lactis viscosus* ADAMETZ, 1889.

Source.—Ropy milk from two creameries in New York State.

Morphology.—This organism is rod shaped in form with rounded ends and possesses a capsule. Owing to its relative shortness it may, upon superficial examination, be mistaken for a micrococcus. The individuals occur singly, in pairs placed end to end, and occasionally in chains. Apparently because of the viscid nature of the capsule, cover-glass preparations show a tendency for the organism to associate in groups of varying size. The paired arrangement is most commonly met with. In young cultures especially where active multiplication is taking place the

individuals are either spherical in form or short rods exhibiting the various stages of segmentation.

There is a great variation in size depending upon the medium and age of the culture. In an agar slant eight days old the spherical forms vary from .6 to .8 μ. in diameter, while the elongated forms which predominate in numbers vary from 8. .to 1.2 μ. in breadth and from 1.2 to 2 μ. in length. In a bouillon culture three days old great variation in size occurs, the predominating form measuring 1 to 2 μ. in breadth and from 2 to 3 μ. in length.

In all old cultures forms occur which differ widely from those in growing cultures. Involution forms, approximately circular in outline and measuring from 2 to 3 μ. in diameter, may appear singly or in pairs. Rods measuring about 1.2 μ. in width and from 2 to 4 μ. in length are occasionally present. Long chains are frequently found in cultures three weeks old. Some thread like forms occur which show no indication of division into separate individuals.

The organism stains readily with the aniline dyes in common use. It exhibits an irregular arrangement of the cellular protoplasm when stained with carbol fuchsin. This feature is more or less noticeable in individuals from all of the culture media, but is most conspicuous in bouillon (See plate). When treated by the Gram method the stain is retained. The capsule does not stain when treated by the common methods, but preparations made from milk by extracting the fat with ether and staining with carbol fuchsin show the capsule especially well as an unstained area surrounding each individual. The presence of the capsules can be positively demonstrated by Welch's glacial acetic acid method and by the Gram method.

The organism probably possesses slight motility, but the motion is so feeble that it is with difficulty distinguished from the Brownian movement. Motility is best observed in young milk cultures. The viscid nature of the growth presents difficulties which may have prevented the demonstration of flagella. In view of the uncertainty concerning the presence of motility this is unfortunate.

Biologic characters.—This bacillus is a strict aërobe. It grows

readily in the presence of air upon all of the ordinary culture media. The minimum temperature at which growth will occur, is below 46° F. (8° C.) and the maximum, at about 104° F. (40° C.) A freshly inoculated milk culture was frozen for twenty hours without destroying its vitality. The cultures which are described below were all grown at room temperature.

Agar.—Growth appears in agar plate cultures in twenty-four hours after inoculation as circular gray colonies 1 to 2 mm. in diameter. Young colonies are opalescent and exhibit the phenomonon of diffraction of light. Mature colonies may be irregular in contour, flat, with sharply defined borders, and grayish white in color. Under low magnification no distinctive marking is apparent. The growth is viscid so that the substance of the colony adheres to the platinum needle and spins out into a fine thread. After several weeks, when the culture media has dried perceptibly, the viscid character tends to disappear, the colony becoming more pasty in consistency. In such old cultures, faint concentric markings are visible near the border.

The young growth upon the surface of slanted agar is opalescent and usually consists of numerous small confluent colonies. Later, when the growth thickens, the opalescent appearance is not noticeable. The condensation water becomes cloudy, viscid, and after considerable evaporation has occurred, brown in color. Growth in slant cultures of glycerine agar presents no distinctive features.

Fifteen per cent gelatin.—Surface colonies appear first as minute gray points upon the surface of the medium. Under a low magnification they are granular and show concentric, circular markings. Older colonies are approximately circular with a sharply defined border, and distinct circular markings. Some have a pronounced central protuberance surrounded by a thinner border, while others consist of a hemispherical mass alone. The colonies, at first whitish in color and opalescent, later become distinctly yellow. The growth is viscid like that of agar, but upon drying somewhat, the colony adheres to the platinum needle and becomes detached from the surface of the medium. The gelatin is not liquefied even after long standing. In ten per cent gelatin the growth is more luxuriant. Sub surface colonies appear

as small whitish points. Gelatin stab cultures exhibit a white growth extending along the line of puncture. This is composed of minute, closely set whitish colonies, and is more vigorous near the surface. The surface growth in stab cultures presents no important features.

Bouillon.—In twenty-four hours after inoculation alkaline bouillon becomes slightly clouded and somewhat viscid. A thin gray growth adheres to the sides of the tube at the surface of the liquid, and if the culture is allowed to stand undisturbed, a thick extremely viscid pellicle forms after about a week. It extends gradually from the outer border of the surface towards the center. Upon displacing the pellicle, the liquid underneath is found to be much less viscid. When the culture is agitated daily, the pellicle does not form and the liquid becomes uniformly viscid throughout. A quantity of white, tenacious sediment is deposited. The reaction is alkaline constantly. Cultures a month old or more are extremely turbid, slightly yellowish in color, and contain considerable whitish viscid sediment. The growth is as vigorous in acid boullion as in the above and the reaction becomes alkaline in two days or less.

One per cent solution of sugars in bouillon contained in fermentation tubes.—In glucose, lactose, and saccharose bouillon growth occurs only in the bulb and the constricted U shaped portion leading to the closed arm. In each one the growth is discontinued abruptly at the base of the closed arm, showing the organism to be an obligate aërobe. The reaction in each is alkaline to litmus. Gas is not formed in any of the cultures.

Potato.—Twenty-four hours after inoculation a thin growth appears, which is distinguished with difficulty, being of the same color as the potato. Later, the growth becomes more abundant and viscid, assuming a drab color.

Blood serum, slanted.—The growth first appears as a yellowish, viscid mass occupying the line of inoculation, and eventually spreads over the moist portions of the medium. In the upper portions of the slanted serum, where there is relatively less moisture, the spreading of the growth is more restricted. Tree-like branches grow out and anastomose with one another forming a net work which covers the surface of the medium to a greater or less extent.

Milk.—The cream on the surface of milk becomes noticeably viscid in twelve hours after inoculation. The milk below, while plainly ropy in young cultures, does not exhibit the maximum viscosity until several weeks have elapsed. In old cultures the milk will spin out in opalescent, gossamer-like threads frequently a yard long. If one of these fine threads be allowed to come in contact with a cover-glass and be examined microscopically, the milk will be found swarming with bactèria arranged in long chains. Only after considerable evaporation has occurred do milk cultures assume a semi-fluid consistency. The reaction, at first alkaline to litmus, becomes feebly acid after about two months.

In separator skim milk, additional appearances become apparent, due probably to the relatively smaller per cent of fat present. The milk promptly becomes viscid like whole milk, and remains so during the succeeding changes. After about a month the liquid gradually becomes translucent and opalescent throughout. This appearance, together with the alkaline reaction and the entire absence of fat globules, shown upon microscopic examination, indicates that saponification has occurred. In some cultures this change has been observed to occur first at the surface and later to extend downwards in a gradually broadening zone. A relatively large deposit of white precipitate occurs.

Indol.—An indol reaction is doubtful.

Thermal Death Point.—Freshly inoculated bouillon cultures remain sterile after exposure to a temperature of 58° C. for ten minutes. Exposure for the same length of time to a temperature one degree less, fails to kill the organism.

Disinfectants.—Duplicate tests conducted during the month of October show that a drop of buillon culture dried upon a cover-glass is rendered sterile by exposure to direct sunlight for three hours. Experiments conducted during January show that seven hours are required to accomplish the same result in mid-winter. Bacteria from a bouillon culture dried upon cover-glasses, have retained their vitality for a month when kept in the dark.

Experiments with a solution of powdered soap widely used in creameries do not indicate that that substance possesses disinfecting powers in the strength ordinarily used in dish washing.

Sufficient c. p. sulphuric acid was added to a four weeks old bouillon culture to make a five per cent solution. Inoculations in bouillon from this mixture after a lapse of one minute and after longer intervals, indicated by their failure to show growth, that five per cent sulphuric acid is rapidly fatal to *Bacillus lactis viscosus*.

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The Following Bulletins are Available for Distribution to Those Who may Desire Them.

40 Removing Tassels from Corn, 9 pp.
41 Steam and Hot-Water for Heating Greenhouses. 26 pages.
49 Sundry Investigations of 1892, 56 pp.
53 Œdema of the Tomato, 34 pp.
55 Greenhouse Notes, 31 pp.
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69 Hints on the Planting of Orchards, 16 pp.
71 Apricot Growing in Western New York, 26 pp.
72 The Cultivation of Orchards, 22 pp.
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75 Peach Yellows, 20 pp.
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146. Fourth Report of Progress on Extension Work. 28 pp.
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149. Some Spraying Mixtures. 8 pp.

Bulletins Issued Since the Close of the Fiscal Year June 30, 1898

150. Tuberculosis in Cattle and its Control.
151. Gravity or Dilution Separators.
152. Studies in Milk Secretion.
153. Impressions of Fruit-Growing Industries.
154. Table for Computing Rations for Farm Animals.
155. Second Report on the San José Scale.
156. Third Report on Potato Cultnre.
157. Grape-vine Flea-beetle.
158. Source of Gas and Taint Producing Bacteria in Cheese Curd.
159. An Effort to Help the Farmer.
160. Hints on Rural School Grounds.
161. Annual Flowers.
162. The Period of Gestation in Cows.
163. Three Important Fungous Diseases of the Sugar Beet.
164. Peach Leaf-Curl.
165. Ropiness in Milk and Cream.

Bulletin 166. **March, 1899.**

Cornell University Agricultural Experiment Station,

ITHACA, N. Y.

AGRICULTURAL AND CHEMICAL DIVISIONS

Sugar Beet Investigations for 1898

This picture is from a photograph of the experimental beet plats on the Cornell University farm, taken October, 1898.

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CORNELL UNIVERSITY, ITHACA, Feb. 18, 1899.

HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

Sir:—This bulletin, the second on sugar beet culture is published under Chapt. 68 Laws of 1898.

Part I has been written by Mr. John L. Stone, Part II, by Mr. L. A. Clinton, and Part III, by Mr. G. W. Cavanaugh and Mr. A. L. Knisely.

Mr. Stone has been in charge of the field experiments in the 15 counties which by mutual agreement between the state station at Geneva and the Commissioner of Agriculture were assigned to the Cornell Station.

Part I discusses the lessons of 1898 as seen by careful and frequent inspection of the beets in the field. A comparison is made of hilly, stony and level lands with reference to beet culture. Influence of soil on beet production, seeding, depth of planting, early tillage, distance between rows, distance of plants in the row, early and late planting, influence of preceding crop are all discussed and conclusions drawn from the facts secured by observing the plants while growing, and by weighing, measuring and analyzing the crop.

Fungous and insect enemies of the beet are discussed briefly. For a full report of three important fungous diseases of the sugar beet "Root Rot," "Leaf Spot" and "Beet Scab," see Bulletin 163, by B. M. Duggar, which is really a supplemental report of the investigations in beet culture made during the year.

The lessons learned while present when many fields of beets were being harvested are set forth, and the quality, yield of beets per acre, and the cost per acre of the growing and the cost per ton are fully tabulated.

The influence of fertilizers on yield and quality and the influence of variety on quantity and quality are fully noted.

It is found that the farmer himself is the greatest single factor in the profitable production of beets, therefore something has been said along this line.

Part II contains a brief statement of the investigations conducted on the University farm, and which to be at all reliable required daily personal attention.

Comparatively small areas were used that the variation of soil conditions might be eliminated so far as possible.

The land has a well known history for the last five years, and had been thoroughly mixed by artificial means and then separated into small plats of four by five feet, each plat separated from the others by means of water tight walls which extend to a depth of more than two feet.

The investigations were along six principal lines as follows :

1. Effects of thin and thick planting.
2. Effects of moderate and extra tillage.
3. Effects of thinning at various periods.
4. Effects of subsoiling.
5. Variety tests.
6. Fertilizer tests.

Part III contains a brief account of the chemical work. In addition to the 496 analyses of beets, several analyses of soil upon which beets were grown and samples of fertilizers used have also been made.

The average sugar content in the juice in 1898 was 15.29 per cent ; purity 83.6 ; in 1897, 16.91 per cent ; purity 83.5 and sugar in the beet 14.53 per cent, and 16.06 per cent for the two years, respectively.

Comparisons are made of the sugar in beets grown on sandy loam and clay loam soils. There is also appended tables showing the weather conditions and precipitation for 1897 and 1898 which are valuable.

The past season was peculiar in many respects. Unusual precipitation occurred in many localities about planting time and this was followed by severe drought when the beets were nearly half grown, and this in turn was followed by abnormal conditions at harvest time. The precipitation in October was 1.5 inches and temperature 2.8° above the average. Harvest was delayed and many beets were not gathered until November when the conditions were made still more difficult by continued abnormal precipitation.

The Secretary of Agriculture, Hon. James Wilson, the Commissioner of Agriculture, Chas. A. Weiting, Dr. H. W. Wiley, of Washington, and Dr. W. H. Jordan, Director of the State Experiment Station, Mr. J. E. Rogers, President of the Binghamton Beet Sugar Co., and many earnest farmers have all given valuable assistance in the extended work carried on during the year.

I. P. ROBERTS,
Director.

OBSERVATIONS AND CONCLUSIONS

BASED UPON A STUDY OF FIELD CONDITIONS.

BY J. L. STONE.

The investigations in sugar beet culture, carried on by this Station in 1897 seemed to give quite decided indications that there was much land in the state that could grow large crops of beets and that the beets would be of a quality highly satisfactory to the manufacturer.

No data were obtained as to the cost of growing the crop. It was well understood that a majority of the lands which seemed suited to sugar beets were in the hands of farmers who were accustomed to work three horses abreast attached to heavy machinery designed to turn off a large amount of work in a short time. The sugar beet is an exacting crop and requires a considerable amount of close, careful tillage necessarily somewhat slow and tedious. In fact sugar beet growing may more properly be classed as gardening rather than as farming. In view of these facts the question arose very distinctly. "Will these farmers develop the patience and skill of the gardener quickly enough to enable them to grow sugar beets at a profit before they shall become discouraged on account of the failures that many of them are sure to make?"

Therefore, the work of 1898 was planned with a view, not only of duplicating last seasons investigations, but of ascertaining what it cost different growers for the labor employed in securing their crops.

In accordance with arrangements made with the State Department of Agriculture at Albany, and the N. Y. State Experiment Station at Geneva, the Cornell University Agricultural Experiment Station conducted experiments with sugar beets, in 1898 in the following counties: Niagara, Orleans, Monroe, Genesee, Livingston, Wyoming, Erie, Chautauqua, Cattaraugus, Allegany, Steuben, Chemung, Tompkins, Tioga and Broome.

In these counties 1,113 lbs. of sugar beet seed were distributed to 417 farmers, and 21 one-pound lots were distributed to appli-

cants outside these counties. Thus 438 farmers were connected with the work and 1,134 lbs. of seed were distributed. The larger part of these farmers received one pound each of seed, the object being to observe in a general way the growing of the beets on the different farms and to ascertain the percentage of sugar in the different samples. Thus far the work was a duplication of that of last year.

With about 125 farmers arrangements were made to grow plats of one-half acre or more, keeping a careful record of all the labor bestowed upon them. Instructions in regard to growing the beets were given in circular No. 15, which was accompanied by a blank for keeping the records. Many of the farmers were supplied with several varieties of seed for the purpose of making a variety test. About 40 of them received sacks of fertilizer for a fertilizer test. A representative of the Station visited nearly all of these plats during the season and some of them that were easily accessible were inspected frequently.

Later in the season Circular No. 17, was issued giving instructions in regard to harvesting, ascertaining yield and sending samples for analysis.

The small number of complete reports that have been received from the farmers growing these beets is somewhat disappointing. Some of the crops were complete or partial failures. This was due to a variety of causes operating in different cases, but though they were failures as crops they were instructive as experiments.

In more cases the farmers at some time during the season lost track of the labor account and were unable to report cost. In still other cases the farmers being pressed with work at harvest time, owing to the unfavorable weather conditions, failed to get as accurate records of yield as are necessary that their reports should be of greatest value. Still we have many valuable reports and the season's work as a whole is very instructive.

In the report of last year (Bulletin 143, pp. 493-517) were given "General Remarks on Sugar Beet Cultivation." The suggestions there made are sustained by this season's experience. Some points need to be further emphasized while others may be modified to suit the condition of particular cases. It is proposed to call attention to such lessons as have become

apparent by a careful inspection and study of the experimental areas as well as many fields of beets grown for the factories.

The Binghamton Beet Sugar Co., Binghamton, N. Y., planned and carried out a very complete system of inspection and records of the fields of beets grown under contract for their factory. These records, through the courtesy of the company, have been open to the inspection of representatives of this Station and have furnished part of the data upon which are based many of the conclusions stated in this bulletin.

LESSONS FROM THE 1898 SUGAR BEET FIELDS.

Hilly land.—It is not wise to attempt to grow beets on hilly land. The seed-bed must be thoroughly fined; the plants start rather slowly and it is some time before they afford much protection to the soil. In the meantime heavy rains are likely to occur and serious damage will result from washing. Some fields were reworked and planted to other crops and others were partial failures from this cause the past season. The crop on the University farm was materially injured in this way.

Stony land.—Avoid stony land. The beets require close cultivation, and small stones interfere with this and increase the expense. Nevertheless some very satisfactory crops, both as to yield and cost, were grown on land that when inspected by the Station representative was noted as "too stony for beets." These farmers knew their soil and were somewhat experienced in growing similar crops, and their skill enabled them to secure better results than were obtained by some others on far more favorable land. The credit is to the farmer and not to the soil.

Kind of soil.—The heavier grades of soil seem to have been more favorable in 1898 than the lighter ones. The drought of this year came in July and though not of long duration, on account of the intense heat and high winds, was severe. The beets evidently had not yet thrust their roots very deeply into the soil, and those on light land were greatly damaged. Those on heavier soils seemed to suffer less and recovered more completely when the rains came. The drought of 1897 came later in the season, and although much more prolonged and apparently

more severe, the beets were not so much affected by it, and those on light soils seemed not to suffer more than those on the heavy.

Preparation of the land.—In no one way did farmers make mistakes that cost them so heavily in expense of tillage or yield of crop as by failure to properly prepare the land. On some lands subsoiling is desirable ; on all lands deep plowing and thorough fitting are necessary for satisfactory results. Land well prepared is more than half tilled. It is believed that more fall plowing should be done. Heavy land is especially benefitted by fall plowing. If this can be done early enough to get a start of crimson clover or rye as a cover crop, so much the better; only do not make the mistake of deferring the spring plowing till the cover crop has made large growth. Should dry weather come on soon after seeding, any considerable amount of coarse material turned under would so interfere with the rise of water from below into the surface soil as to hinder germination and growth.

Seeding.—Most growers used from 12 to 15 lbs. of seed per acre in 1898, and there is a great variety of opinions among them as to what is the proper amount. Where the conditions were favorable for germination the beets came up many times too thick, and some of the farmers propose to reduce the amount of seed used, partly to save expense, but more especially to save the labor of thinning. Where the conditions were unfavorable to germination an uneven stand was secured and some of these farmers propose to use 20 to 25 lbs. of seed per acre to secure a stand. It is believed that both of these extremes are unwise. If the conditions are so unfavorable that 15 lbs. do not give a stand, it is doubtful if 25 lbs. will produce the desired result. On the other hand, while three or four pounds would be abundant if nearly all of it grew, and the labor of thinning would be materially reduced, still it is unsafe to risk getting a stand from so small an amount of seed. Twelve to fifteen pounds of seed per acre are still recommended.

Depth of planting.—In some cases too deep planting resulted in a failure to get a stand. Early in the season, while the soil is cool and moist, deep planting should especially be avoided. One-half inch at this time is deep enough. It is well to have a narrow press-wheel follow the seeder and firm the soil directly over

the seed while leaving the rest of the surface loose. Heavy showers soon after planting, followed by sunshine will often cause a crust to form that the young plants cannot break through. The alert farmer should discover this condition and break up this crust with a weeder, or some similar tool, before serious damage has resulted.

Early tillage.—A serious mistake was made by many growers by deferring the first working of the soil till the plants had attained considerable size and strength. As soon as the rows can be followed a hand cultivator (or lacking this a hand hoe) should be used to loosen the soil near the plants and check any weeds that may be attempting to gain a foothold. Again, some failed to do the thinning till the plants were too large. Not only were the plants injured by the removal of those taken out, but the labor involved in thinning these overgrown beets is several times what it would be if the work were done at the right time. Bunch the plants with a narrow hoe when they are from one-half inch to one and a half inches high, and thin them to one in a place when they are two to three inches high. Frequent light tillage is the secret of economically keeping ahead of the weeds, but as a rule beets receiving horse culture made better growth than those receiving hand culture only. The deeper tillage seems to be favorable for best results.

Distance between rows.—It is not necessary that the rows shall be more than 20 inches apart to allow of thorough horse culture. Still many farmers found difficulty in tilling rows of this width with the equipment and skill at their command. To such it is recommended that the distance between rows be increased for a season or two till they have acquired more experience and skill with the crop. It is confidently believed that they will return to the closer planting after a few seasons' experience. See p. 441

Early and late planting.—The advantage of early or late planting depends very much upon the character of the weather that follows, which of course cannot be foreseen. The past season the late planting gave the best average stands, and as it was thought that there was plenty of time to make sufficient growth the late planting was looked upon with favor. These fields had a very promising appearance during August and September and

were kept free from weeds with less labor than the earlier plantings. However, at harvest time it was found that many of them had not made satisfactory growth and were not sufficiently matured to produce beets of high quality. As a result of the season's observations it is recommended to plant as early in May as the soil becomes warm and in thoroughly good condition. When careful farmers think the soil fit for corn planting, then the beet seed should be put in.

Effect of the preceding crop.—With a great number of varying conditions affecting the growth of the crop, it is, perhaps, unwise to attempt to ascribe a definite result to the influence of the preceding crop. It is only when large numbers of cases can be compared that this is permissible. From a study of the records of the Binghamton Beet Sugar Co. we discover that in 294 cases where both the previous crop and the yield per acre are given, the beets obtained were in the following order and relations, counting the largest average yield at 100.

INFLUENCE OF THE PRECEDING CROP ON THE YIELD OF BEETS.

	Preceding crop.	No. of cases.	Relative yields.
1.	Cabbage	32	100
2.	Clover sod	25	82
3.	Sod, other than clover	25	78
4.	Potatoes	100	73
5.	Corn	100	66
6.	Buckwheat	12	64

In seems from the above figures that cabbage is a crop especially desirable to precede a crop of beets. This probably is owing to several considerations. First, manure is usually applied freely for the cabbage crop and the land is left more fertile than after most other crops. Second, the thorough and late tillage required by the cabbage are particularly beneficial in preparing the land for a succeeding crop, and third, the farmer who has learned to successfully grow cabbage is already well on the road to successful sugar beet culture. True, there is little of the slow tedious work in cabbage growing that is often necessary in beet culture, yet the cabbage grower has very well learned the

importance of thorough preparation of the land and thorough tillage.

It has been quite generally advised in the past not to grow beets on sod ground. But the experience of the last two seasons leads to the conclusion that sod, both clover and other, makes desirable beet land in New York. Unusual care, however, must be taken in the preparation of sod land for beets. It should be plowed early, the autumn or summer before is preferable, and very thoroughly fitted. If plowed late, the interposition of the inverted sod between the subsoil and the seed bed will prevent the free rise of moisture for a time, and should dry weather follow planting, germination and growth will be much retarded. Almost total failures clearly attributable to this cause were observed the past season. It will be observed that among the crops noted, buckwheat seems to be the least desirable to precede beets. It is not thought that the buckwheat itself is in any way harmful to the beet crop, but buckwheat is rarely planted on the best lands and it is assumed that the fertility of these fields is lower than that of fields that had been planted to other crops. In general it may be stated that the more exacting, as to fertility and tillage any crop is, the more desirable it is as a preparatory crop for beets.

Enemies of the beet crop.—In certain quarters, during the season, three species of insects were found preying upon the plants and the indications were that they might, under favorable conditions become destructive. So far as observed no considerable amount of damage was inflicted by any one of them during the past season.

The banded flea-beetle (*Systena taeniata*) was found quite abundantly at LeRoy and Darien in Genesee County, where it wrought some damage to several fields of beets. The blue-flea-beetle (*Systena hudsonias*) was found on the beet field at the University Farm, but did not appear in sufficient numbers to inflict serious damage. The beet-leaf miner (*Pegomyia vicina*) was observed in many fields, but in no case in sufficient numbers to result seriously. The entomological division has these pests and some others under close surveillance, and should they prove troublesome will no doubt be able to suggest methods of successful combat.

Three fungus diseases, root rot of beets (*Rhizoctonia Betæ* Kühn.), leaf spot of the beet (*Cercospora beticola* Sacc.) and beet scab (*Ospora scables* Thaxter.),also made their appearance in sufficient abundance to attract attention, and in a number of cases to inflict considerable damage. These have received prompt attention by the Botanical Division and the result is embodied in Bulletin 163, to which the reader is referred for further information.

Harvesting the crop.—The labor involved in harvesting the crop of sugar beets seems to be greater than most farmers have anticipated. The excessive rains of the autumn, though they caused the roots to be lifted from the soil more easily, made it much more difficult to get them reasonably free from dirt, or to draw them from the fields, and added very much to the discomfort of the workmen while performing the somewhat tedious work of removing the tops and crowns. Better weather and more experience will no doubt permit the work to be done with greater despatch. It is suggested that a more general use of bushel crates in handling the beets will facilitate the labor.

Quality of the beets grown in 1898.—The beets analyzed in 1897 averaged 16.06 per cent of sugar in the beet and 83.5 per cent purity. In speaking of the high quality indicated by these figures, on page 496, Bulletin 143, it is stated: "It is known that some seasons are more favorable to a high quality of beets than others, and perhaps the past season, notably dry in August, September and October, produced beets of more than normal richness. It will not be surprising then if the high quality of beets secured this season is not maintained in the future with different weather conditions while the beets are maturing."

The season of 1898 was very different from that of 1897. Instead of being "notably dry in August, September and October," the precipitation during these months was very much above the normal (see p. 467). In some localities it was almost impossible to get on the land to take off the crop. It is not surprising then that the percentage of sugar in the beet is reduced to 14.53, a falling off of 1.53 per cent in sugar from last year. The purity remains practically the same (see p. 455). It may be assumed that we have experienced in these two years one of the most favorable and one of the most unfavorable seasons for

quality of beets, and it is gratifying to note that the quality is maintained well above the minimum requirement for profitable manufacture.

Yield of beets per acre in 1898.—The number of reports received from farmers giving definite data in regard to yield per acre and the cost of growing the crop is very much smaller than was anticipated. From various causes, as explained elsewhere, they had at some time in the season lost track of the data and then the records were abandoned. Of the reports received forty-four give carefully ascertained yields from areas of one-fourth acre and upward, very few of them being less than one-half acre. From an examination of these forty-four reports the following is obtained:

Six report yields of less than 9 tons per acre.
Ten report yields of 9 or over but less than 11 tons per acre.
Four report yields of 11 or over, but less than 13 tons per acre.
Thirteen report yields of 13 or over, but less than 15 tons per acre.
Seven report yields of 15 or over, but less than 18 tons per acre.
And four report yields of over 18 tons per acre.

The smallest yield reported is 6.1 tons, the largest, 21.33 tons and the average, 12.98 tons per acre.

As to the character of the season—whether favorable or unfavorable—many more farmers pronounced it unfavorble than fair. Very wet early, it interferred with timely planting and securing a good stand. This was followed by very dry weather before the beets were thoroughly established and had sent their roots deep into the soil. A severe check to growth was experienced, and the operation of thinning resulted in damage to the plants that were left. When the late rains came they were so excessive that in some cases damage resulted. It would seem doubtful, therefore, if the past season should be rated as "fairly favorable."

From the field book of the Binghamton Beet Sugar Co. is taken the list of farmers appended below. Their names, post offices, area of beets grown and the yield per acre of trimmed beets obtained are given. These crops represent quite a large area, coming from about a dozen counties. Very many farmers did not do as well as these, but the list is so large and the area covered is so wide that it leaves no doubt but that most farmers may

do as well when they shall have learned how to grow beets. None of these farmers have had previous experience in growing beets and it does not necessarily follow that they are more skillful than some others who did not succeed so well. True, the thorough, painstaking farmer is more likely to succeed at first than the careless, but until more experience is had with the crop much will depend upon a fortunate timing of the work and selection of land.

YIELDS OBTAINED BY SOME OF THE FARMERS GROWING SUGAR BEETS FOR MANUFACTURE.

Name.	Post office.	Acres grown.	Yield per acre. Tons.
Adams, S. B.	Sherburne	2	10.8
Albertson, C.	Waverly	1	11.7
Ainsley, G. W.	Binghamton	1 1/8	12.6
Armstrong, S. E.	Unadilla Forks	1	17.6
Babcock, C. L.	Fulton	1	20.5
Bascett, G. S.	Coopers	1	11.2
Beardsley, R. E.	Elmira	2	10.9
Becker, P.	Central Bridge	1	13.2
Bidleman, J. F.	Chemung	1 1/4	12.3
Bowman, W.	Baldwinsville	1	21.0
Boyce, P. H.	Corning	2	11.5
Branard, C. M.	Stockwell	1	16.7
Brand, Jno.	Elmira	2	21.3
Brown, A. W.	Unadilla Forks	2.5	14.8
Brown, G. A.	Pitcher	1	11.7
Brumsted, Chas.	Batavia	1	12.7
Buell, O. A.	Sherburne	1	12.5
Berry, H. W.	W. Winfield	1	10.3
Caple, P. J.	Cattatunk	3	13.8
Cardner, P. R.	Tulley	2	17.1
Carley, A. W.	Binghamton	1	13.4
Carpenter, G. F.	Lindley	1	12.6
Carr, F. J.	Tully	1	12.5
Carrier, E.	Corfu	1	13.5
Caccada, M. F.	Wells Mills	1	10.6
Chamberlain, E.	Southport	1	14.2
Chamberlain, Geo.	Elmira	2	10.9
Clark, E.	Tully	1	10.2
Clark, G. H.	Cooperstown	3	10.9
Colliere, F. J.	Preble	1	12.3
Corbett, M. J.	Corbettville	1	12.7

Crawford, E.	Milford	1.5	11.4
Cummings, C. J.	Tully	1	22.1
Cummings, O. J.	Preble	1	16.2
Curtin, D. E.	Tully	1	14.2
Daley, Frank	Preble	1	14.9
Darby, L. D.	Milford	1	12.9
Davadge, Jas.	Binghamton	6	12.1
Davison, Chas. S.	Elmira	3	12.4
Dietz, P. B.	Barnesville	2	10.9
Duglace, Geo.	Candor	2	13.7
Dunham, H. W.	Nichols	1	11.3
Edgecomb, G.	Waverly	1.5	14.7
Elmer, J. C.	Presho	1	15.9
Elmer, S.	Presho	1	14.1
Ellis, Spencer	Unadilla	1	11.3
Ensign, D.	Killawog	1	10.7
Evans, R. W.	Riverside	1	12.6
Fenderson, G. L.	Lounsberry	1	13.8
Foote, J.	Sherburne	1	11.7
Foster, Jas.	Sherburne	3	20.2
Fuller, D. L.	Corning	1	10.2
Gates, C. H.	Unadilla Forks	1.5	11.9
Gates, J. A.	Killawog	1.5	10.2
Gay, F. J.	Preble	1	15.9
Giddins & Son,	Baldwinsville	1	13.0
Groton, S. W.	Lavonia	4	10.1
Haley, M. H.	Waverly	1	19.9
Hall, Jno.	Homer	1	14.8
Hanson, A. B.	Windsor	3	12.4
Harden, Benj.	Southport	1	14.2
Harper, L. G.	Darien	1	14.9
Harrington, W. D.	Lowman	1	13.3
Harris, J. H.	Elmira	2	12.6
Hanen, A. G.	Sangerfield	1	14.6
Hazard, J. H.	Himrods	1	17.4
Hemsbrought, E.	Campville	1	11.6
Hedlerman, Thos.	E. Bethany	1	11.2
Hovey, C. C.	Bainbridge	1	11.9
Hoyt, S. T.	Corning	2	14.6
Jarvis, I. S.	Hartwich Line	1	10.3
Jones, Theo.	Baldwinsville	1	15.2
June, A. K.	Port Crane	1	14.9
Karkritz, Chas.	E. Corning	1	15.3
King & Long,	Tully	1	17.3
Knapp, A. A.	Preble	1	12.8
Knapp Bros.,	Deposit	1	12.1

Knapp, C. A.	Homer	2	12.0
Kneale, Chas.	Horseheads	1	10.2
Kuhl, R. V.	Lawrenceville, Pa	1	13.9
Lamb, W. G.	E. Harrington	1	21.6
Lane, Geo. S.	Lounsberry	1	15.1
Leaman, A.	Central Bridge	1	14.0
Littlewood, G. H.	Lisle	1.5	11.2
Lasee, R. R.	Laurens	1	15.9
Lowman, M.	Wellsburg	1	14.8
Martin, H. S.	Binghamton	3	11.6
McCauley & Smith,	Horseheads	2	12.3
McMurdy, W. J.	Binghamton	2	17.3
McNamara, T.	Sangerfield	1	16.6
McQueen, H. H.	Horseheads	1	17.4
Millers Bros.,	Elmira	5	17.6
Montague, C. D.	Campnelle	1	12.6
Oxie, W.	Homer	1	15.4
Murphy, J. C.	Horseheads	2	14.2
Nelson, H.	Pavillion Center	1	11.2
Newcomb, C. A.	Rathbone	1	24.0
Newcomb, J. H.	Addison	1	13.3
Nye, M. S.	Preble	1	13.4
Newton, C. O.	Hameb	4	13.8
Odell, G. D.	N. Birdgewater	1	12.4
Outt, S. D.	Preble	1	18.7
Park, A. D.	Osborne	3	16.8
Parkinson, T. W.	N. Bridgewater	1	15.6
Phoenix, L. J.	Addison	1	14.2
Plunkett, E. F.	Lindley	1	13.1
Powell, J. G.	Elmira	1	12.9
Pumpelly, G. N.	Owego	6	13.3
Quinn & Co.	Sherburne	5	10.9
Rackly, W. J.	Seely Creek	1	21.0
Randall, W. N.	N. Bridgewater	1	18.7
Rathbun, A. T.	Wellsburg	1	12.1
Riehlman, F.	Otisco	1	11.7
Risley, J. M.	Cassville	3	16.1
Roberts, W. C.	Windsor	1	13.5
Rood, W. C.	Center Lisle	1	11.3
Rowland, W. H.	Bridgewater	1	16.1
Ray, W. J.	Southport	2	14.4
Saunders, Henry	Horseheads	2	14.5
Shafer, Geo. A.	Cobleskill	2.25	13.2
Sherwood, H.	Addison	1	13.3
Smith, Chas.	Big Flats	2	11.4
Smith, J. J.	Candor	1	11.2

Smith, W. C.	Candor	1	14.2
Smith & Powell	Syracuse	15	15.3
Snell, F. W.	Chemung	1	18.1
Shrague, C. R.	Binghamton	1	11.0
Squires, H. C.	20 Cortland Street, N. Y.	2	11.6
Stage, Clarence	Wellsburg	3	13.8
Stebbins, H. D.	W. Winfield	1	16.0
Stermer, Jno.	Big Flats	1	19.4
Swart, C. S.	Cobleskill	2	13.0
Swartout, G. R.	Harwick Seminary	1	11.8
Taylor, N. D.	W. Winfield	2	13.9
Thomas, G. H.	Chenango Bridge	1	20.3
Thompson, D. G.	Corning	2	12.7
Tracy, Matt.	Tully	1	11.6
Treat, R. S.	Horseheads	1	22.6
Tuckerman, G.	Cassville	2	16.0
Treyon, F. C.	Peoria	1	14.6
Vanderburg, W. D.	Preble	1	11.1
Van Duser, J. S.	Horseheads	8	14.3
Vincent, G. S.	Scott	1	11.8
Van Housen C.	Tully	1	12.1
Waddell, C. R.	W. Winfield	1	12.1
Weed, J. B.	Binghamton	6	15.9
Wellman, A. E.	Covington	1.5	13.0
Wells, G. M.	Big Flats	2	11.4
Westlake, L. D.	Horseheads	1	15.6
Wilcox Bros.,	Horseheads	1	18.2
Williams Bros.,	W. Winfield	1	12.0
Wright, Robt.	Little York	2	14.7

These 152 farmers planted 252 acres of beets and harvested an average of 14 tons of trimmed beets per acre.

Cost of growing an acre of beets.—Arrangements were made with more than one hundred farmers to keep careful records of the number of hours of labor of teams, men or boys employed in growing their fields of beets. Blanks were furnished for keeping the data and making reports. They were instructed to charge up this labor at the usual price in their localities. Only forty-five reports complete in this respect have been received. The figures given do not include the cost of seed, fertilizer or the use of land. Of the 45 farmers

4 report the cost as less than $25 per acre.
6 report the cost as between $25 and $30 per acre.
12 report the cost as between $30 and $35 per acre.

7 report the cost as between $35 and $40 per acre.
3 report the cost as between $40 and $45 per acre.
1 reports the cost as between $45 and $50 per acre.
4 report the cost as between $50 and $55 per acre.
2 report the cost as between $55 and $60 per acre.
5 report the cost as over $60 per acre.

The lowest cost reported is $10.20 per acre, the highest $83.00 and the average, $38.15.

As was expected the range of cost per acre is very wide and is affected by many circumstances. It was attempted to observe these fields very carefully to determine if possible the conditions that contribute to excessive cost. Many of these conditions have already been referred to under their proper headings. Among others that remain to be mentioned attention is especially called to the necessity of timeliness in doing the work. This applies all through the season and to every operation, but especially to thinning and weeding during the early periods of growth. There is a time when these operations can be performed at the minimum of cost, and sometimes the delay of a week will double or even quadruple the expense of getting the crop in proper condition. Perhaps the highest skill of the grower is manifested by wise management in this respect.

Another mistake made by many was in tilling the crop by hand instead of horse labor. In nearly every case of excessive cost reported it is attributable to one or the other of these causes. As a result of this season's observations it is believed that when the farmers shall become experienced with the crop $30 to $40 per acre may be named as the probable range of cost.

From the field book of the Binghamton Beet Sugar Co. it is found that the 119 farmers who report the cost of growing the crop up to, but not including the harvest, place the average cost at $16.04 per acre. The cost of the harvest may be placed at $10 to $12 per acre and the total will still be below the minimum suggested above. This leads to the suspicion that only those who were successful in keeping the cost at a low figure reported this item.

Cost of beets per ton.—The cost per ton, depending as it does on both the cost and yield per acre, is affected by every condition influencing the crop during the season. A study of the reports brings to light some interesting features. Some of the highest

costs per acre, leave a possible margin of profit because large crops were secured. The lowest cost per ton ($1.41) is associated with a low yield, (7.20 tons per acre) and is made possible by the exceedingly small amount of expense ($10.20), bestowed upon the crop.

Of the 43 reports in which cost per ton is given,

9 place the cost below $2.00 per ton.
15 place the cost between $2.00 and $3.00 per ton.
10 place the cost between $3.00 and $4.00 per ton.
5 place the cost between $4.00 and $5.00 per ton.
4 place the cost above $5.00 per ton.

The lowest cost is $1.41, the highest $7.52, and the average $3.25 per ton.

The high cost of $7.52 per ton is only possible by the association of high cost per acre with a small yield. The conditions that brought about this particular result are not likely to recur with experienced growers, nor are we likely to find many cases where an expenditure of only $10.20 per acre will produce any profit in sugar beet growing. More than half of these reports place the labor cost of a ton of beets at less than $3.00, but the average is drawn above that figure by a few cases of excessive cost.

Effect of fertilizer upon yield.—The Station supplied sacks of fertilizer to a number of farmers to be applied to a part of their experimental area. The sacks contained

58 pounds of dissolved rock guaranteed 14 per cent phosphoric acid.
40 pounds of sulfate of potash, guaranteed 50 per cent potash.
30 pounds of sulfate of ammonia guaranteed 20 per cent nitrogen.

Each lot of fertilizer was intended for a ¼ acre plat, or at the rate of 512 pounds of the mixture per acre, furnishing 24 lbs. of nitrogen, 32½ lbs. phosphoric acid and 80 lbs. of potash. While the effect of the fertilizer was very apparent during the growing period, producing a much more vigorous growth and in several instances resulting in a much better stand of plants, yet it is greatly regretted that only five growers took pains to harvest the fertilized and unfertilized plats separately so as to be able to report comparative yields. Some of these grew several varities of beets, so there were in all 13 plats fertilized and 13 plats unfertilized. The average yield of the fertilized plats was

12.84 tons per acre and of the unfertilized 9.37 tons—a gain of 3.47 tons per acre in favor of the fertilized plats. In some instances the gain was very much more marked than in others and was profitably secured. On the average the gain just about paid the cost of the fertilizer and the labor of handling the extra tonnage of beets. In the second and third columns of the following table is given the respective yields obtained from the fertilized and unfertilized plats :

INFLUENCE OF FERTILIZER UPON YIELD AND QUALITY OF BEETS.

(When several varieties were grown fertilized and not fertilized, the average of the fertilized and not fertilized plats is used.)

Name of Grower.	No. of varieties averaged.	Yield, tons per acre.		Sugar in beets, per cent.		Purity.	
		Fertilized.	Not Fertilized.	Fertilized.	Not Fertilized.	Fertilized.	Not Fertilized.
D. H. McLallen, Trumansburg	4	10.95	7.59	15.31	14.51	84.4	82.7
C. E. Chapman, Peruville	3	18.61	11.81	16.98	15.03	86.7	83.3
C. D. Cartwright, Darien..	3	12.43	10.17	17.50	16.59	86.1	86.5
L. R. Rogers, Albion.....	2	10.43	7.03	16.77	16.34	88.8	88.0
F. R. Thompson, Westfield	1	11.80	10.25	16.15	15.06	89.9	88.5
C. B. Kershaw, Owego....	1			11.40	11.59	76.4	79.2
C. D. Jackson, Peruville .	1			14.44	14.16	83.0	79.4
J. C. Murphy, Horseheads.	4			13.23	14.42	81.0	84.1
A. J. Howland, Ithaca.....	1			15.77	15.25	80.2	81.5
Average yield of 13 plats by 5 growers..............		12.84	9.37				
Gain in favor of fertilized plats....................		3.47					
Average per cent of sugar and purity of 20 plats by 9 growers..............				15.28	14.74	84.0	83.7

Influence of fertilizer upon quality of beets.—The table given above shows the effect produced by the fertilizer described under the last topic upon the per cent of sugar in the beets and the purity of the juice. Nine experiments gave 20 plats fertilized by the side of 20 plats unfertilized. The average per cent of sugar in the beets produced on the former was 15.28 and on the latter 14.74, a difference of .54 in favor of the fertilized plats. The average purity of the juices obtained from the former was 84

and from the latter 83.7, a difference of .3 in favor of the fertilized plats.

Influence of variety upon yields of beets.—A large number of farmers were supplied with several varieties of beet seed, but unfortunately very few of them harvested the varieties separately so as to be able to note comparative yields. The following table gives the yields obtained by six farmers with from two to four varieties each. It seems that there is comparatively little difference in the yielding quality of the varieties named.

INFLUENCE OF VARIETY UPON YIELD OF BEETS.

(When more than one plat of a variety were grown by the same person the average is used.)

Experimenter.	Tons per acre.			
	Klein-wanz-lebner.	Vilmorin.	Schrei-ber's German.	Zeringen.
D. H. McLallen, Trumansburg......	9.72	10.61	8.82	7.41
Wm. Heyward, Stafford....	8.46	8.31	8.81	9.71
C. E. Chapman, Peruville..........	13.04	14.47	18.13	
C. D. Cartwright, Darien............	12.38	10.28	11.25	
Miss E. R. Hall, West Perrysburg ..	16.55	14.37	13.50	
L. R. Rogers, Albion	9.13	8.33		
Averages of 6 cases, two varieties..	11.57	11.06		
Averages of 5 cases, three varieties	12.07	11.61	12.10	
Averages of 2 cases, four varieties..	9.09	9.10	8.81	8.56

Influence of variety upon quality of beets.—On p. 453—is given the averages of all the analyses made of several leading varities used in the experiments this season. It has been thought best to present here some of the results obtained where these varieties were planted side by side, all of the conditions except variety being the same.

INFLUENCE OF VARIETY UPON QUALITY OF BEETS.

(When more than one plat of a variety was grown by the same person the average is given.)

	Kleinwanzlebener.		Vilmorin.		Schreiber's German.		Zeringen.	
	Per ct. sugar in beets.	Purity.	Per ct. sugar in beets.	Purity.	Per ct. sugar in beets.	Purity.	Per ct. sugar in beets.	Purity.
D. H. McLallen, Trumansburg.	15.06	86.5	13.65	80.8	16.41	85.3	14.53	81.4
Miller Bros., Elmira..........	14.49	86.6	14.25	82.8	16.15	87.2	15.30	88.9
J. C. Murphy, horseheads.	12.78	78.1	13.78	82.8	14.70	86.3	13.72	82.3
S. S. Cole, Cuba	14.35	80.8	15.39	86.2	15.77	87.4	15.20	87.9
E. G. Fenton, Fenton.........	14.35	87.3					15.53	87.9
C. E. Chapman, Peruville	16.20	86.6	14.58	84.8	16.32	84.4		
C. D. Cartright, Darien........	16.84	85.4	16.60	85.0	17.69	88.5		
W. B. Kneebone, Franklinville	17.10	89.1	15.11	81.9	18.19	89.1		
J. Jenks, Le Roy..............	15.30	85.2	15.30	83.8	14.63	86.5		
E. R. Hall, W. Perrysburg....	16.06	82.8	16.72	86.7	17.10	90.0		
C. M. Lusk, Lisle.............	15.84	87.3	14.96	84.8	16.48	87.4		
S. A. Ingersoll, Owego........	13.97	85.0	14.25	83.8	13.78	84.3		
C. H. Andrews, Owego........	13.78	83.3	12.83	78.5	14.63	84.6		
G. E. Merill, Sheridan	13.11	81.2	13.11	82.1				
Chas. Barlow, Le Roy.........	15.08	87.1	13.35	77.2				
N. Wheeler, Arkport..........	15.34	88.7	15.11	84.5				
L. R. Rogers, Albion.........	16.96	90.1	16.15	86.8				
Average of 16 plats.........	15.14	85.8	14.69	83.3				
Average of 12 plats.........	15.15	85.5	14.78	83.5	15.99	86.9		
Average of 5 plats	14.21	83.9					14.86	85.7
Average of 4 plats	14.17	83.0	14.27	83.1	15.76	86.5	14.69	85.1

We give below a list of the farmers who have carefully recorded the data relating to their crops and forwarded to us the reports upon which much of the foregoing is based. They have the thanks of the Station for their coöperation and the farmers of the state owe them a debt of appreciation. Many others grew crops that were instructive but some of the data was lacking and reports were not forwarded to the Station, or if forwarded were not sufficiently complete to be available for tabulation.

List of Farmers Who Furnished Detailed Reports on Their Sugar Beet Crops.

ALLEGHANY CO.

Cole, S. S.	Cuba
Morgan, C. H.	Cuba

BROOME CO.

Hazzard, G. E.	Upper Lisle
Lusk, C. M.	Center Lisle
Mercereau, M. L.	Union
Witherill. Dr. L. D.	Union

CATTARAUGUS CO.

Clements, Geo.	Franklinville
Davies, Thos. H.	Fairview
Hall, Ellen R.	West Perrysburg
Kneebone, W. B.	Franklinville
Kales, J. W.	Franklinville

CHAUTAUQUA CO.

Fenner, M. M.	Fredonia
Thompson, T. R.	Westfield

CHEMUNG CO.

Murphy, J. C.	Horseheads

ERIE CO.

Fenton, E. G.	Fenton

GENESEE CO.

Barlow, Chas.	Le Roy
Cartwright, C. D.	Darien
Jinks, Jacob	Le Roy
Hayward, Wm.	Stafford
Stutterd, J. F.	Stafford
Tillotson, F. A.	Pavilion

LIVINGSTON CO.

Barber, Aaron	Avon
Caff, W. H.	Wadsworth
Jacobs, S. H.	Mt. Morris

MONROE CO.

Curtis, Chas. E.	Hilton
Demming, H. C.	So. Greece
Smith, I. W.	Hilton

NIAGARA CO.

Hinman, Edw.	Lockport

ONONDAGA CO.

Barnes, E. A.	Baldwinsville
Guereau, C. H.	Baldwinsville
Van Wie, Levin	Baldwinsville

ORLEANS CO.

Allis, Clark	Medina
Howell, H. B.	Medina
Morgan, B. F.	Albion
Phipps, H. E.	Eagle Harbor
Rogers, L. R.	Albion
Staines, Chas. F.	Albion
Wyley, W. S.	Albion

STEUBEN CO.

Graves, B. J.	Ingleside
Hayt, S. T.	Corning
Wheeler, N.	Arkport

TIOGA CO.

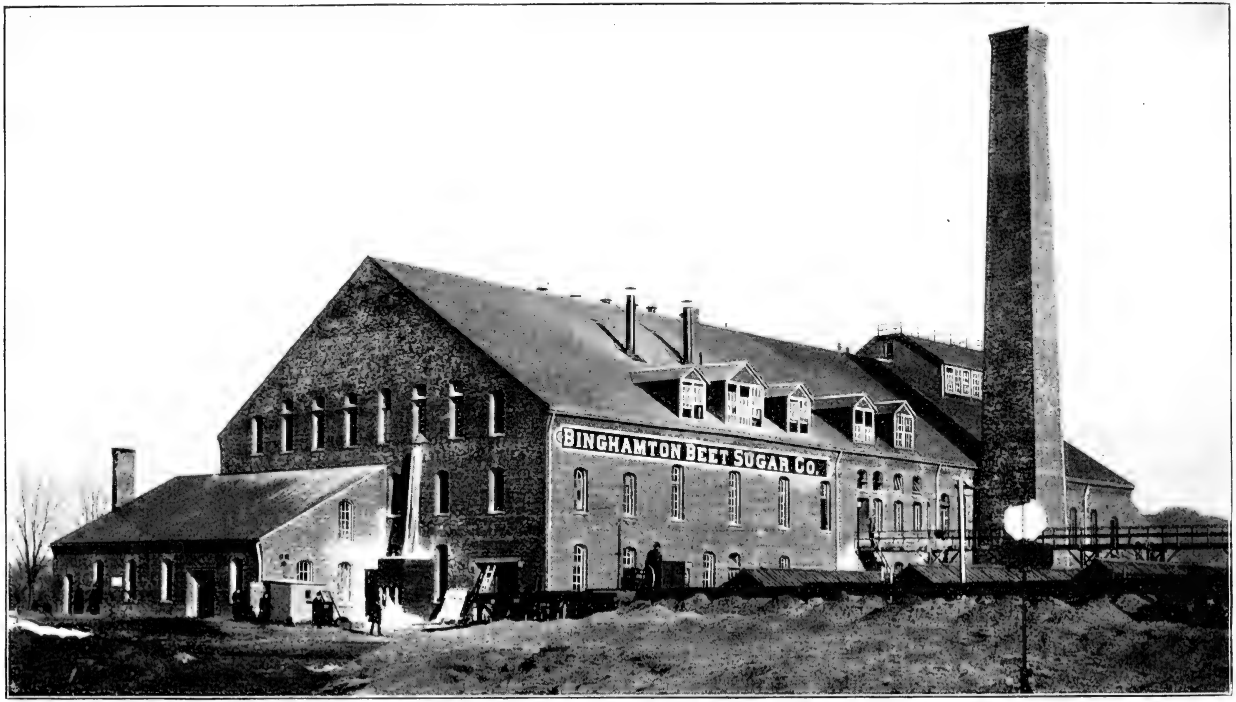
Goodrich, Stephen	Owego
Ingorsoll, Geo. A.	Nichols
Kershaw, C. B.	Owego

TOMPKINS CO.

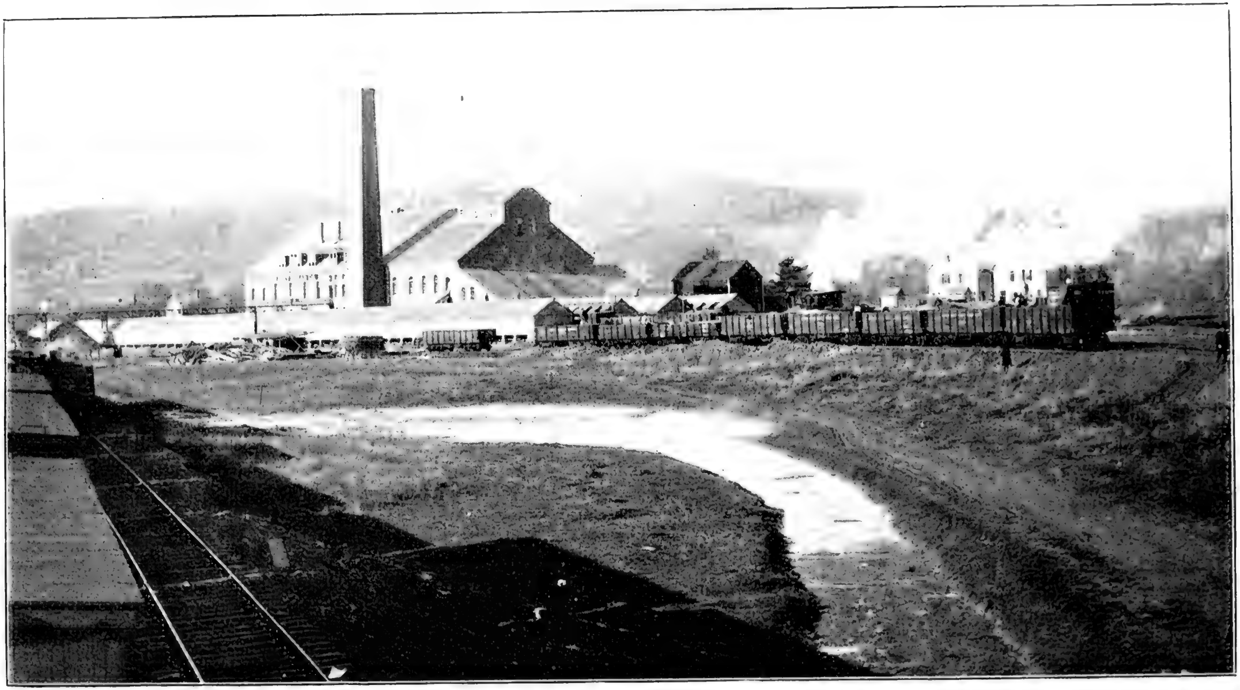
Chapman, C. E.	Peruville
Cornell University Farm	Ithaca
Howland, A. J.	Ithaca
Jackson, C. D.	Peruville
McLallen, D. H.	Trumansburg

WYOMING CO.

Matteson, Geo.	Orangeville
Treyon, F. C.	Peoria



73.—*Factory of the Binghamton Beet Sugar Co., Binghamton, N. Y. (Pile of beet pulp in the foreground.)*



74.—*The Binghamton Factory from the southwest.*

Part II.

EXPERIMENTS WITH SUGAR BEETS AT THE CORNELL UNIVERSITY EXPERIMENT FARM, 1898.

BY L. A. CLINTON.

In bulletin No. 143 of this Station was published results of fertilizer experiments with sugar beets in 1897. In 1898 it was decided to conduct in addition to the fertilizer experiments, investigations relating to the culture of beets. The following lines of investigation were decided upon :

1. Rows 24 inches apart and beets thinned to 6 inches in the row compared with rows 20 inches apart and thinned to 9 inches in the row.
2. Effects of tillage.
3. Effect of bunching and thinning at various periods of growth.
4. Effect of subsoiling the land immediately previous to planting.
5. Test of varieties.

Wide Planting of Rows vs. Narrow Planting—It is generally recommended that beets be planted in rows 20 inches apart. Most farmers are not familiar with the methods of tillage required when rows are so planted. If the rows could be planted at a distance apart of 24 inches it would very much facilitate culture, especially until the farmers become familiar with intensive methods required in sugar beet production. Plats 33 and 34 of the permanent series of plats were selected for the work. These plats have for five years been heavily cropped and no fertilizer has been applied since the winter of 1893–4. The soil is gravelly loam and especially subject to effects of droughts. Land was plowed in the fall and replowed in the spring. The following table shows the results from the two plats :

Plat No.	Date planted.	Date thinned.	Dates cultivated.	Date harvested.	Yield per acre.
33, rows 20 inches apart.	May 11	June 1	June 1–6 17–24 July 12–28	Oct. 27	20 tons
34, rows 24 inches apart.	May 11	June 1	June 1–6 17–24 July 12–28	Oct. 27	18 tons

On plat 33 the beets were thinned in the row to distances of 9 inches, and on plat 34 the space left between beets in the row was 6 inches, thus securing approximately the same number of plants per plat. While in the early stages of growth the tillage of the rows which were 24 inches apart was somewhat simplified, yet on the whole the rows which were 20 inches apart were easier kept clean, and after becoming somewhat familiar with their cultivation no trouble was experienced. Where the land is in proper condition for sugar beet growing the rows should be not more than 20 inches apart. The table above shows that where rows were 20 inches apart the yield per acre was two tons more than where rows were 24 inches apart. All conditions were alike as nearly as they can be made in field culture, and the results were decidedly in favor of the close planting of rows.

Effect of tillage on beets.—Tillage has shown such marked results upon certain crops which have been experimented with that it was thought wise to determine if equally marked results could be obtained upon sugar beets. Plats 35 and 36 of the regular series were devoted to the work. Each plat was divided into three areas each of which would contain three rows of beets, each row being 109 feet long. The following diagram shows the arrangement of rows:

Diagram of Plat 35.		
	Discard row.	
	1	Cultivated 6 times.
	2	
	3	
	Discard row.	
	4	Cultivated 5 times.
	5	
	6	
	Discard row.	
	7	Cultivated 4 times.
	8	
	9	
	Discard row.	

Plat 36 was a duplicate of 35.

The soil is fairly uniform on the two plats, and was given the same preparation. The variety of beets grown was the Kleinwanzlebener. The following table shows the number of cultures given the various areas and their results :

No. of plat.	Date planted.	Date thinned.	Date harvested.	Yield per acre. Tons.	Per ct. of solids in juice.	Per ct. of sugar in juice.	Per ct. Purity.	Per ct. of sugar in beet.
35 1st Division, 6 cultures.	May 11	June 2	Oct. 27	17.6	19	16.70	87.9	15.87
35 2nd Division, 5 cultures.	May 11	June 2	Oct. 27	23.6	19.5	16.95	86.9	16.10
35 3rd Division, 4 cultures.	May 11	June 2	Oct. 27	18.8	21.1	18.20	86.3	17.29

Following table shows the results obtained from a duplicate of the above experiment.

No. of plat.	Date planted.	Date thinned	Date harvested.	Yield per acre. Tons.	Per ct. of solids in juice.	Per ct. of sugar in juice.	Per ct. Purity.	Per ct. of sugar in beet.
36 1st Division, 6 cultures.	May 11	June 2	Oct. 27	14.8	20.9	18.25	87.3	17.34
36 2nd Division, 5 cultures.	May 11	June 2	Oct. 27	22	19.1	16.70	87.4	15.87
36 3rd Division, 4 cultures.	May 11	June 2	Oct. 27	18.8	19.5	16.20	83.1	15.39

Average yield per acre from 6 cultures, 16.2 tons.
Average yield per acre from 5 cultures, 22.8 tons.
Average yield per acre from 4 cultures, 18.8 tons.

The data given above are from experiments which are too limited to warrant our drawing conclusions as to the number of cultures best adapted to give good results with sugar beets. While in this experiment five cultures resulted in the largest yield yet it would be erroneous to draw the conclusion that five cultures

would always give the best yield. The conditions as determined by soil, rainfall, previous treatment of land, etc., would all need to be considered. This experiment will be continued to learn if more definite data can be obtained.

Effect of bunching and thinning at various periods of growth.—It is usually recommended that beets be thinned at about the time the second pair of leaves appear. It is found in practice that it frequently is impossible to thin the beets at the time recommended. The experiment was undertaken to learn if it is important that beets be thinned at a certain time in their growth or if considerable range in time may be taken. The variety of beets grown was Kleinwanzlebener, and the plat selected was No. 39 of the permanent series of plats. The following table shows the results :

Plat No.	Date planted.	Date thinned.	No. of cultures.	Date harvested.	Yield per acre. Tons.	Per ct. of solids in juice.	Per ct. of sugar in juice.	Per ct. Purity	Per ct. of sugar in beet.
39 1st Division	May 11	June 3	6	Oct. 28	22.3	19.5	16.80	86.1	15.96
39 2nd Division	May 11	June 10	6	Oct. 28	23	18.8	16.35	87.	15.53
39 3rd Division	May 11	June 17	6	Oct. 28	28	17.	14.35	84.4	13.63

A study of the above table shows that the yield per acre was considerably more where the thinning was delayed until the beets had made considerable growth. This indicates that where conditions are favorable considerable range may be taken as to time of thinning. With the weather cool and the soil moist thinning may safely be done when the beets have attained a height of three to four inches. However, thinning is such a slow process that it would better be commenced on time, viz., when the second pair of leaves appear the plants should at least be bunched. The bunches may then safely be allowed to remain for a week or ten days before the beets are thinned to a stand of one beet in a place. If one could always be certain that the weather would be cool

and the soil moist then there would not be the imperative necessity for beginning thinning early. If thinning be delayed until there exists drought accompanied by hot weather the growth of the plants may be seriously impaired, if the plants are not entirely destroyed.

Effect of subsoiling immediately preceding planting.—In 1897 it was thought that subsoiling the land immediately preceding planting resulted injuriously to the growth of the beets. To determine the effect of subsoiling under the conditions which might prevail in 1898 plat No. 40 was selected as a suitable place for the test. Immediately before planting, one-half of the plat was subsoiled deeply, and the soil thoroughly loosened to a depth of about 15 inches. Seven rows of beets each 109 feet long and 20 inches apart were planted respectively upon the half of the plat subsoiled and upon the half not subsoiled. The result of the experiment is shown in the following table:

Plat 40.	Date planted.	Date thinned.	No. of cultures.	Date harvested.	Yield per acre. Tons.	Per ct. of solid in juice.	Per ct. of sugar in juice.	Per ct. Purity.	Per ct. of sugar in beet.
7 rows, not subsoiled...	May 11	June 5	6	Oct. 28	22.4	17.	14.35	84.4	13.63
7 rows subsoiled	May 11	June 5	6	Oct. 28	25.3	17.1	14.25	83.3	13.54

The seven rows which were subsoiled gave an increased yield of nearly three tons per acre. The good results following subsoiling were without doubt due in part to the fact that the soil was abundantly supplied with moisture during the early period of growth. Before the severe drought of July the subsoil had become sufficiently compacted so that capillarity was restored and the plants were enabled to draw moisture from below. Where subsoiling is done the same season of planting it is important that it be done early so that capillarity may be restored before the advent of the usual summer drought.

Test of varieties.—Several varieties of beet seed were sent here from various sources with the request that we make a test. This test was made on Plats 41 and 42 of the permanent series of plats. The soil is quite uniform in these plats and all conditions as to preparation, planting, tillage, etc., were alike. The result of the variety test is shown by the following table:

VARIETY TEST.

Plat No.	Date planted.	Variety.	No. of cultures.	Date harvested.	Yield per acre. Tons.	Per cent of solids in juice.	Per cent of sugar in juice.	Per cent Purity.	Per cent of sugar in beet.
41 1st Division.	May 11	Vilmorin Improved, Schlitte & Co.	6	Oct. 28	18	17.1	14.25	83.3	13.54
41 2d Division.	May 11	Zeringen.	6	Oct. 28	19.6	18.	15.55	86.4	14.77
41 3d Division.	May 11	Kleinwanzlebener.	6	Oct. 28	22	17.9	14.90	83.2	14.16
41 4th Division.	May 11	Zeringen.	6	Oct. 28	19.2	19.5	16.40	84.1	15.58
41 5th Division.	May 11	Vilmorin's White Improved.	6	Oct. 28	16.8	16.5	13.00	78.8	12.35
42 1st Division.	May 19	C. Baumier's Kleinwanzlebener.	6	Oct. 28	18	17.8	15.6	87.6	14.82
42 2d Division.	May 19	Pitzschkes Elite.	6	Oct. 28	18	18.6	16.55	89.0	15.72
42 3d Division.	May 19	Kleinwanzlebener from Vilmorin Andrieux & Co.	6	Oct. 28	17.4	17.5	14.05	80.3	13.35
42 4th Division.	May 19	French, very rich, from Vilmorin, Andreux & Co.	6	Oct. 28	21	17.5	14.95	85.4	14.20

The average of results from the 24 plats of various varieties and with various methods of culture was as follows :

AVERAGE OF 24 PLATS.

Yield per acre Tons.	Average wt. of beets analyzed Pounds.	Per cent of solids in juice.	Per cent of sugar in juice.	Purity.	Per cent of sugar in beet.
20.3	1.29	18.7	16.06	85.6	15.13

The above record of results shows a high average for the entire area. No fertilizer of any kind has been used on the land since winter of '93–4 when about 10 loads of strawy barn manure were applied per acre. The land has been heavily cropped every year, and while especially subject to effects of droughts, by proper tillage moisture has been conserved and satisfactory crops harvested. The lesson which should be drawn from the experiments is not so much in the variation between the various plats compared as in the unformly high of all plats. It simply enforces that by thorough preparation of the land and by thorough tillage better results than the average can be obtained.

Experiments with fertilizers for sugar beets.—Experiments with fertilizers on sugar beets were conducted in 1898 upon the "Brick yard" plats. The construction of these plats was described in Bulletin 143 but it is thought well to repeat the description. "In experiments with fertilizers a frequent source of error lies in the fact that the soils of the different plats lacks uniformity and hence the fertilizers appplied do not each have equal opportunity to exercise its full effect. To obviate this difficulty the plats upon which the beets were grown were prepared in the following manner. The soil selected was a gravelly loam and had been cropped heavily for three years without the application of any fertilizer or manure. In the spring of 1897 a space was measured off for fourteen plats each 4 x 5 ft. in size. The soil of this whole area was then removed to a depth of 24 inches, each layer of eight inches being thrown out upon boards by itself. A solid brick cement wall was constructed around each

plat and to a depth of two feet below the surface of the ground. This wall was constructed so that there would be no possible chance for the beets in one plat to receive the benefit of the fertilizer applied to any other plat. After the construction of the wall the soil which had been removed was replaced in the inverse order of its removal, the eight inches removed last was returned first so that it would occupy its original place at the bottom. Before being returned each eight inches of soil was thoroughly mixed and then an equal number of pounds was put into each plat and packed. In this way all the plats were filled, each layer of soil after having been thoroughly mixed was returned to its original position."

Fertilizer experiments were continued upon these same plats in 1898, each fertilizer being applied to the plat which received similar fertilizer in 1897.

The table on page 449 gives the record of the plats and the results for 1898.

The plats upon which these experiments were conducted were so limited in area that no estimate is given of the yield per acre. The object of the experiment was to determine what effect if any, the various fertilizers would have upon the quality of the beets grown. The most noticable effect is seen on Plat No. 6, where nitrate of soda was applied. The per cent of sugar and the per cent of purity falling considerably below that of the other plats.

Where more than one chemical were used they were combined in equal proportions and all fertilizers were thoroughly incorporated with the soil before the seed was planted. The results would seem to indicate that the use of nitrate of soda is conducive to the growth of large beets of poor quality. When used it should be in combination with other chemicals unless the soil is markedly deficient in nitrogen.

BRICK YARD PLATS, FERTILIZER EXPERIMENTS, 1898.

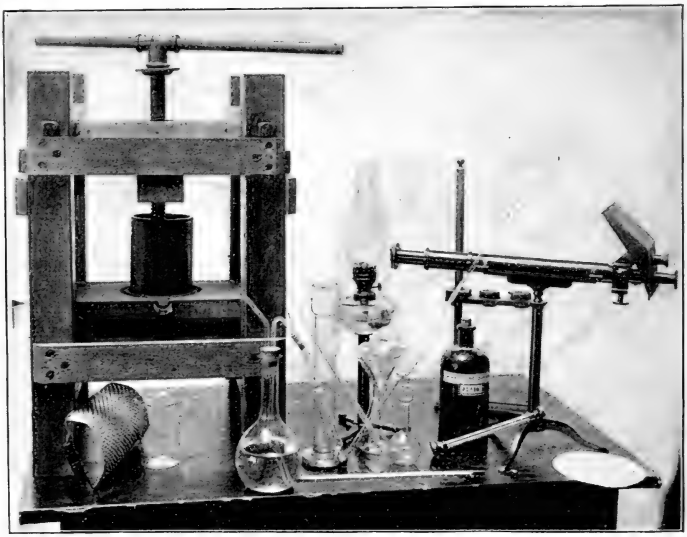
	Date planted.	Variety.	Fertilizer used.	Rate per acre.	Date analyzed.	Av. wt. of beets analyzed.	Per cent of solids in juice.	Per cent of sugar in juice.	Per cent Purity.	Per cent of sugar in beet.
Plat 3	June 10	Kleinwanzlebener	Sulphate of potash	1089 lbs.	Nov. 19	.92	20.6	17.65	85.7	16.77
Plat 4	June 10	Kleinwanzlebener	Superphosphate	1089 lbs.	Nov. 19	.65	20.1	17.25	85.8	16.39
Plat 5	June 10	Kleinwanzlebener	Sulphate of potash Nitrate of soda	1089 lbs. 1089 lbs.	Nov. 19	.91	20.4	17.60	86.3	16.72
Plat 6	June 10	Kleinwanzlebener	Nitrate of soda	1089 lbs.	Nov. 19	1.11	18.4	14.50	78.3	13.78
Plat 7	June 10	Kleinwanzlebener	No fertilizer	1089 lbs.	Nov. 19	.89	20.5	17.	82.9	16.15
Plat 8	June 10	Kleinwanzlebener	No fertilizer	1089 lbs.	Nov. 19	.70	20.4	17.95	88.0	17.05
Plat 9	June 10	Kleinwanzlebener	Sulphate of potash Superphosphate	1089 lbs. 1089 lbs.	Nov. 19	.60	21.6	18.90	87.5	17.96
Plat 10	June 10	Kleinwanzlebener	Nitrate of soda Superphosphate	1089 lbs. 1089 lbs.	Nov. 19	.84	21.1	18.45	87.4	17.53
Plat 11	June 10	Kleinwanzlebener	Sulphate potash Nitrate of soda Superphosphate	1089 lbs. 1089 lbs. 1089 lbs.	Nov. 19	.73	20.3	17.35	85.4	16.48
Plat 12	June 10	Kleinwanzlebener	Muriate of potash	1089 lbs.	Nov. 19	.56	21.2	18.40	86.8	17.48
Plat 13	June 10	Kleinwanzlebener	Lime	1089 lbs.	Nov. 19	.65	20.1	17.60	87.5	16.72
Plat 14	June 10	Kleinwanzlebener	Ground phos. rock	1089 lbs.	Nov. 19	.65	19.5	16.85	86.4	16.01

PART III.

THE WORK OF THE CHEMICAL DIVISION.

BY A. L. KNISELY AND G. W. CAVANAUGH UNDER THE DIRECTION OF G. C. CALDWELL, CHEMIST.

The work of the Chemical Division has been carried along lines very similar to those of a year ago. Samples of beets have been received from several hundred farmers. In most cases the samples were accompanied by reports of the experimental plats.



75. *Apparatus used in the analysis of Sugar Beets.*

The first step in the analysis of sugar beets is to obtain a sample of juice. This process is similar to cider-making. The beets are grated on an ordinary grater, lying under the press. The pulp obtained, about one pint, is put in the cylinder of the press and the juice pressed out flows into the glass cup or beaker under the spout. The juice is then poured into the tall glass cylinder at the left of the lamp. The temperature of the juice must be found with the thermometer, which lies on the table in front of the cylinder. The density or solid matter of the juice is next found by means

of the hydrometer, or Brix spindle; this spindle lies against the press with its base at the bottom of the glass cylinder.

The next step is to put a definite amount of the beet juice into the 100 cubic centimeter flask. This flask with a long slender neck and wide mouth is just at the left of the bottle marked "poison." This definite amount of juice is measured out by the large pipette which is just at the left of the bottle and leans against the polariscope. The juice is very dark colored and the coloring matter must be removed. A little of the sub-acetate of lead in the bottle, added to the measured juice in the flask will cause the coloring matter and impurities to coagulate and settle. In front of the lamp is a funnel holding a folded filter paper. The juice is poured into this filter and the clear filtrate is caught in the flask which supports the funnel, whilst the impurities and coloring matter are held back on the filter paper. The juice which runs through the filter paper is just as clear as water and is now ready for analysis (polarization).

In front of the sub-acetate bottle is a glass tube about eight inches long with glass caps on either end that can be screwed on. One of the glass caps is removed, the tube is filled with the clear juice and the cap is replaced so that one can look through the tube endwise. At the extreme right is the saccharimeter, a very costly piece of apparatus. The tube full of juice is put into this saccharimeter in a dark room and the lamp is lighted and placed just in front of the instrument. On looking through the telescope one can see the light of the lamp; the line of vision passes endwise through the tube full of the clear beet juice. By carefully noting how any particular beet juice in the tube affects the rays of light passing through it, we can tell immediately what per cent of sugar there is in that particular juice.

In front of the press is a flask called a wash bottle, containing pure water. Such a bottle is needed always in chemical work.

At the extreme right of the cut is a pile of white filter papers used in filtering juices.

The samples of beets were analyzed as soon as received, or as soon after as possible and in each case a *franked report blank** was filled out giving the analysis of the sample. This report was sent back to the farmer who had sent in the sample for analysis. In this way each experimenter quickly learned the quality of his beets.

The results of the season's work have been carefully tabulated,

*These report blanks are the size and shape of ordinary postal cards. On the face they have the mark of the U. S. Government which exempts them from postage; on the opposite side is the blank form ready to be filled in with the results of the analysis. These blanks were kindly supplied to the Station by Dr. H. W. Wiley, Chemist of the U. S. Dept. of Agriculture.

but it has been thought best not to publish again this year a series of exhaustive tables, but rather to state in a concise form some of the final results of the season's work.

In summarizing the work it is necessary to use the terms "total solids," "sugar in juice," "sugar in beet," and "purity;" therefore for the benefit of readers in general these terms are here defined.

1. *Per cent total solids in the juice, or degrees Brix.*—Beet juice consists of water, and of solid matter containing sugar, mineral salts, coloring matter, nitrogenous compounds, etc. A beet juice is said to have 19.9 per cent total solids. This means that 19.9 per cent of that juice is solid matter and the remaining 80.1 per cent is water; or, in other words, in each 100 pounds of such a juice there are 19.9 pounds of solid matter and 80.1 pounds of water.

2. *The per cent of sugar in the juice.*—This per cent is determined by the polariscope. A beet juice is said to analyze 17 per cent sugar. This means that in each 100 pounds of such a juice there are 17 pounds of pure sugar.

3. *The per cent of sugar in the beet.*—The per cent of sugar in the beet is obtained by multiplying the per cent of sugar in the juice by $\frac{95}{100}$. Thus 17 per cent sugar in juice $\times \frac{95}{100} = 16.15$ per cent sugar in the beet. This means that in each 100 pounds of such beets without crowns there are 16.15 pounds of pure sugar.

4. *Per cent of purity of a juice.*—This term is often called the coefficient of purity, or better still the quotient of purity. It expresses the ratio between the *per cent of total solids in the juice* and the *per cent of sugar in that same juice.* That is, in any particular juice, the *purity* expresses what proportion of the total solids is sugar. Thus in a juice analyzed, there is found a *purity of 86.6 per cent.* This means that if such a juice were evaporated to dryness and the total solid matter obtained, then of this solid matter 86.6 per cent would be sugar and the remaining 13.4 per cent would be impurities not sugar; or stated in another way, in every 100 lbs. of the solid matter obtained by evaporating the juice, 86.6 lbs. would be sugar and the remaining 13.4 lbs. would be impurities and not sugar.

In any given case the *purity* is obtained by dividing the *per*

cent of sugar in the juice by the *per cent of total solids* and multiplying by 100. The term *purity* is not an indication of the quality of a *juice*, but of the quality of the *total solids* in the juice; that is, it tells *how many parts are sugar in every 100 parts of the total solids.*

We shall now take up, first, the general summary of the season's work and then the condensed reports from each county and lastly the meteorological data for 1897 and 1898.

Four hundred and ninety-six samples have been received and analyzed consisting of the following varieties:

Number of analyses.	Variety.
260	Kleinwanzlebener.
81	Vilmorin.
22	Schreiber's German.
12	Zeringen.
7	Very Rich French.
114	Scattering and unnamed.
496	Total.

Giving our attention to the three leading varieties; the Kleinwanzlebener, Vilmorin and Schreiber's German we find that they ranged in quality as follows:

	Kleinwanzlebener.	Vilmorin.	Schreiber's German.
	Samples.	*Samples.*	*Samples.*
Below 12 per cent sugar in beets.......	15	12	0
Between 12–13 per cent sugar in beets..	32	8	0
Between 13–14 per cent sugar in beets..	44	13	2
Between 14–15 per cent sugar in beets..	48	15	4
Between 15–17 per cent sugar in beets..	99	25	9
Above 17..........................	22	8	7
Total..........................	260	81	22

The averages of all the analyses made during 1898 of each of these three leading varieties are as follows :

	Kleinwanzlebener average of 260 samples.	Vilmorin average of 81 samples.	Schreiber's German average of 22 samples.
Per cent solids in juice..	18.40	18.30	19.60
Per cent sugar in juice..	15.43	15.07	16.96
Per cent sugar in beets..	14.66	14.32	16.11
Per cent purity.........	83.90	82.30	86.50

This table shows that the Kleinwanzlebener is a little better than the Vilmorin in quality. The Schreiber's German has been tried this year for the first time and it seems to be a very promising variety for New York State. The 22 samples analyzed ranged much better than either Kleinwanzlebener or Vilmorin.

Comparing the results of 1898 with those of the season of 1897, when 495 samples were analyzed, we have the following figures. The averages of the two seasons 1897 and 1898, are given side by side so as to be easily compared.

Season 1897. Average of 495 Samples.		Season 1898. Average of 496 Samples.	
Per cent solids in juice.....	20.25	Per cent solids in juice......	18.30
Per cent sugar in juice.....	16.91	Per cent sugar in juice.....	15.29
Per cent sugar in beet......	16.06	Per cent sugar in beet......	14.53
Per cent purity............	83.50	Per cent purity.............	83.60

A comparison of these two seasons suggests the query, why so much difference in the two cases? Why are the beets so much richer in sugar one year than they are another year? Several causes suggest themselves for this. There is a possibility that the quality of the seed this year was not quite so good as that of a year ago. This season a few new varieties were tried and some of them were of a poor quality and hence tended to lower the general averages of the season's work. The temperature of the two seasons varied somewhat and this probably has been an important factor influencing the amount of sugar produced in the beets.

It is thought that the one condition that had most to do with the decrease of sugar in 1898, was the difference in the amount of moisture.

In 1897 the weather was very favorable for the development of the sugar, especially during September and October; the later month being exceptionally dry and just right for the formation of sugar.

In 1898 the later months of the growing season, especially August, September and October, were very wet as compared with the corresponding months of 1897, so that the beets continued to grow more and mature less than in 1897.

In 1897 the temperature for August and September was below the normal, whilst for the corresponding months of 1898 the temperature was considerably above the normal. This excessive warmth together with the over abundant rainfall, would stimulate plant growth and retard the formation of sugar and also prevent the early maturing or ripening of the beets. (For the weather conditions of the state for 1897 and 1898, see pages 466–7.)

In 1897 beets grown on freshly plowed clover sod, were of poorer quality than those grown on land that had been well tilled the preceding year.

An experiment carried on in 1898 by Mr. C. D. Jackson, of Peruville, supports the conclusion drawn in 1897.

Mr. Jackson grew Kleinwanzlebener sugar beets on corn stubble and also on clover sod, both with and without fertilizer, with the following results:

Kind of soil and how treated.	Per cent solids in juice.	Per cent sugar in juice.	Per cent sugar in beet.	Per cent Purity.
Clover sod with fertilizer............	18.0	13.90	13.21	77.2
Clover sod without fertilizer.........	18.5	14.50	13.78	78.4
Corn stubble with fertilizer..........	18.6	16.50	15.68	88.8
Corn stubble without fertilizer.......	19.0	15.30	14.54	80.5

These results are decidedly in favor of planting upon recently plowed corn stubble.

Mr. C. M. Lusk, of Centre Lisle, also experimented along the same line and tested the relative merits of corn stubble and clover sod for producing high quality beets. He experimented with three varieties of beets and got no great difference in quality and the results were somewhat contradictory. They are as follows:

Soil.	Variety of Beet.	Per cent solids in juice.	Per cent sugar in juice.	Per cent sugar in beet.	Per cent Purity.
Clover sod. Corn stubble.	Kleinwanzlebener.	19.6 18.6	16.90 16.45	16.06 15.63	86.2 88.4
Clover sod. Corn stubble.	Vilmorin.	18.6 18.5	15.60 15.90	14.82 15.11	83.8 85.9
Clover sod. Corn stubble.	Schreiber's German.	19.8 19.9	17.50 17.20	16.63 16.34	88.4 86.4

Comparison of sandy and clay loams, eighty-four samples were grown on sandy loam, and 48 samples on clay loam. The averages of the results from these two types of soil are as follows:

	Sandy loam. Average of 84 samples.	Clay loam. Average of 48 samples.
Per cent solid in juice....	18.20	18.60
Per cent sugar in juice...	15.24	15.44
Per cent sugar in beet....	14.48	14.67
Per cent purity...........	84.30	84.10

These results would seem to indicate that there is little or no difference between *clay loam* and *sandy loam* for producing beets of high quality. The sugar content of the juice is 0.2 per cent higher on clay loam, whilst the purity is 0.2 per cent higher on sandy loam.

On the following pages are given the results of the season's (1898) work by counties. The work has been greatly condensed and a few of the general averages only are presented.

In cases where but few experiments are recorded, one must guard against drawing too sweeping conclusions. They may often be misleading.

Allegany—Twelve samples were analyzed of which 7 were Kleinwanzlebener and the remainder miscellaneous samples.

The Kleinwanzlebener ranged in quality as as follows:

From 12–13 per cent sugar in beet, 1 sample; 13–14 per cent no sample; 14–15 per cent, 2 samples; 15–17 per cent, 2 samples, above 17 per cent, 2 samples.

These beets were grown mostly on sandy and gravelly loam. The average of the analyses of the 7 samples is as follows:

Per cent solids in juice....................	20.00
Per cent sugar in juice....................	16.71
Per cent sugar in beet....................	15.87
Per cent purity..........................	83.60

The richest beet of the season came from this county and was

a Kleinwanzlebener grown on stiff clay with a hard-pan subsoil. It analyzed as follows :

Per cent solids in juice	23.80
Per cent sugar in juice	21.00
Per cent sugar in beet	19.95
Per cent purity	88.20

Broome.—Fourteen samples were analyzed including 5 Kleinwanzlebener and 4 Vilmorin. The remaining samples were miscellaneous. The quality of these two varieties was as follows :

Between 14–15 per cent sugar in beet 1, Kleinwanzlebener, 2 Vilmorin ; 15–17 per cent, 3 Kleinwanzlebener, 2 Vilmorin ; above 17 per cent 1 Kleinwanzlebener.

The averages of the analyses of these two varieties are given below :

	Kleinwanzlebener. Average of 5 samples.	Vilmorin. Average of 4 samples.
Per cent solids in juice	19.50	18.50
Per cent sugar in juice	17.11	15.70
Per cent sugar in beet	16.25	14.92
Per cent purity	87.70	84.90

Samples were grown mostly on sandy loam.

Cattaraugus. — Twenty-three samples were received consisting of 11 Kleinwanzlebener, 7 Vilmorin and the remainder miscellaneous samples.

The Kleinwanzlebener and Vilmorin varieties ranged in quality as follows :

Below 12 per cent sugar in beet, 1 Kleinwanzlebener, 2 Vilmorin ; from 12–13 per cent, 1 Kleinwanzlebener, 1 Vilmorin ; from 13–14 per cent, 2 Kleinwanzlebener ; from 14–15 per cent, 1 Kleinwanzlebener ; from 15–17 per cent, 4 Kleinwanzlebener, 3 Vilmorin ; above 17 per cent, 2 Kleinwanzlebener, 1 Vilmorin.

Below are given the averages of the analyses of these two varieties :

	Kleinwanzlebener. Average of 11 samples.	Vilmorin. Average of 7 samples.
Per cent solids in juice..........	17.80	17.80
Per cent sugar in juice..........	14.93	14.34
Per cent sugar in beet	14.18	13.62
Per cent purity	83.90	80.60

These varieties were grown chiefly on gravelly and clay loam.

Chautauqua—One hundred and thirty-seven samples were received, consisting of 86 Kleinwanzlebener, 27 Vilmorin and the remainder miscellaneous varieties. Beets ranged in quality as follows: Below 12 per cent sugar in beet, 5 Kleinwanzlebener, 6 Vilmorin ; from 12–13 per cent, 19 Kleinwanzlebener, 3 Vilmorin ; from 13–14 per cent, 18 Kleinwanzlebener, 4 Vilmorin ; from 14–15 per cent, 15 Kleinwanzlebener, 3 Vilmorin ; from 15–17 per cent, 24 Kleinwanzlebener, 7 Vilmorin ; above 17 per cent, 5 Kleinwanzlebener, 4 Vilmorin.

The averages of the analyses of these two varieties are given below.

	Kleinwanzlebener. Average of 86 samples.	Vilmorin. Average of 27 samples.
Per cent solids in juice..	18.00	18.20
Per cent sugar in juice ..	14.86	14.98
Per cent sugar in beet ..	14.12	14.23
Per cent purity.........	82.60	82.30

Of the 86 samples of Kleinwanzlebener, 17 were grown on clay loam, 23 on gravelly to gravelly loam and 10 on sandy to sandy loam. Their quality was as follows :

	Clay loam. Average of 17 samples.	Gravelly loam. Average of 23 samples.	Sandy loam. Average of 10 samples.
Per cent solids in juice..	18.50	18.40	18.10
Per cent sugar in juice..	15.65	15.31	15.19
Per cent sugar in beet...	14.87	14.54	14.43
Per cent purity	84.60	83.20	83.90

Giving our attention to the Vilmorin variety; of the total number received from Chautauqua County, 3 were grown on clay loam, 7 on gravelly loam and 4 on sandy loam. Their quality ranged as follows:

	Clay loam. Average of 3 samples.	Gravelly loam. Average of 7 samples.	Sandy loam. Average of 4 samples.
Per cent solids in juice.	18.50	19.10	19.20
Per cent sugar in juice..	15.23	15.86	16.31
Per cent sugar in beet...	14.47	15.07	15.50
Per cent purity.........	82.30	83.00	84.90

Chemung—Sixteen samples were received of which 6 were Kleinwanzlebener, 4 Zeringen, 3 Vilmorin, and 3 Schreiber's German. With two exceptions these samples were all grown on sandy loam. The averages of the analyses of these several varieties are as follows:

	Kleinwanzlebener. Average of 6 samples.	Vilmorin. Average of 3 samples.	Zeringen. Average of 4 samples.	Schreiber's German. Average of 3 samples.
Per cent solids in juice......	18.20	18.10	17.70	18.20
Per cent sugar in juice......	15.39	15.25	14.75	15.67
Per cent sugar in beet.......	14.62	14.49	14.01	14.89
Per cent purity..............	84.60	84.30	83.30	86.10

Erie — Twenty-five samples were analyzed consisting of 11 Kleinwanzlebener, 8 Vilmorin and the remainder miscellaneous. Giving our attention to the Kleinwanzlebener and Vilmorin varieties we find that they ranged in quality as follows:

Below 12 per cent sugar in beet, 3 Kleinwanzlebener, 2 Vilmorin; from 12–13 per cent, 1 Vilmorin; from 13–14 per cent, 3 Kleinwanzlebener, 1 Vilmorin; from 14–15 per cent, 3 Kleinwanzlebener, 3 Vilmorin; from 15–17 per cent, 2 Kleinwanzlebener, 1 Vilmorin.

The averages of the analyses of these two varieties are given below:

	Kleinwanzlebener. Average of 11 samples.	Vilmorin. Average of 8 samples.
Per cent solids in juice	17.40	17.60
Per cent sugar in juice	14.37	14.29
Per cent sugar in beet	13.65	13.57
Per cent purity	82.60	81.20

Samples grown on *light clay* and *sandy loam* were of better quality than those grown on *heavy clays*.

Genesee—Fifty-five samples were received and analyzed consisting of 29 Kleinwanzlebener, 12 Vilmorin, 6 Schreiber's German and the remainder miscellaneous.

The beets ranged in quality as follows:

Between 12–13 per cent sugar in beet, 1 Kleinwanzlebener, 2 Vilmorin; from 13–14 per cent, 4 Kleinwanzlebener, 2 Vilmorin; from 14–15 per cent, 9 Kleinwanzlebener, 1 Vilmorin, 1 Schreiber's German; from 15–17 per cent, 13 Kleinwanzlebener, 4 Vilmorin, 2 Schreiber's German; above 17 per cent, 2 Kleinwanzlebener, 3 Vilmorin and 3 Schreiber's German.

The averages of the analyses of the three varieties are given below :

	Kleinwanzlebener. Average of 29 samples.	Vilmorin. Average of 12 samples.	Schreiber's German Average of 6 samples.
Per cent solids in juice..	18.80	19.00	20.20
Per cent sugar in juice..	15.87	15.94	17.66
Per cent sugar in beet...	15.05	15.14	16.78
Per cent purity..........	84.40	83.90	87.40

The predominating soils in Genesee County are not heavy, being light clay, sandy and gravelly loams.

Livingston — Ten samples were received consisting of 5 Kleinwanzlebener and the remaining varieties scattering.

Considering the Kleinwanzlebener we have :

One sample below 12 per cent sugar in beet, 3 ranging from 12–13 per cent and 1 sample above 17 per cent sugar.

The average of the analyses is given below :

	Kleinwanzlebener. Average of 5 samples.
Per cent solids in juice.	17.00
Per cent sugar in juice.	13.58
Per cent sugar in beet..	12.90
Per cent purity........	79.90

The soil upon which these samples were grown was chiefly sandy loams.

Monroe—Eight samples were received consisting of 2 Kleinwanzlebener, 3 Vilmorin ; 1 Zeringen, 1 Schreiber's German and 1 unnamed sample.

The averages of the analyses are as follows :

	Kleinwanzlebener. Average of 2 samples.	Vilmorin. Average of 3 samples.	Zeringen 1 sample.	Schreiber's German. 1 sample.
Per cent solids in juice......	19.80	20.00	18.00	20.60
Per cent sugar in juice......	16.15	16.83	14.35	17.25
Per cent sugar in beet.......	15.34	15.99	13.63	16.39
Per cent purity..............	81.60	84.50	79.70	83.70

Niagara — Nine samples were received, of which 6 were Kleinwanzlebner, 2 Vilmorin and 1 unnamed.

The Kleinwanzlebener ranged in quality as follows :

One sample between 13–14 per cent sugar in beet, 3 ranging from 14–15 per cent and 2 from 15–17 per cent.

The average of the analyses of the Kleinwanzlebener is given below.

	Kleinwanzlebener. Average of 6 samples.
Per cent solids in juice.	18.30
Per cent sugar in juice.	15.49
Per cent sugar in beet..	14.72
Per cent purity	84.60

Orleans — Seventeen samples were received, consisting of 13 Kleinwanzlebener and 4 scattering varieties.

The quality of the Kleinwanzlebener ranged as follows :

One sample below 12 per cent sugar in beet, 1 between 13–14 per cent, 2 between 14–15 per cent, 7 ranging from 15 to 17 per cent and 2 above 17 per cent sugar.

These Kleinwanzlebener gave an average analysis as follows:

	Kleinwanzlebener. Average of 13 samples.
Per cent solids in juice.	19.20
Per cent sugar in juice.	16.48
Per cent sugar in beet..	15.66
Per cent purity........	85.80

These samples were all grown upon light soils, chiefly sandy loams.

Steuben—Nine samples were received consisting of 8 Kleinwanzlebener and 1 Vilmorin.

Of the Kleinwanzlebener, 1 sample ranged between 13–14 per cent sugar in beet, 1 from 14–15 per cent, 5 from 15–17 per cent and 1 sample above 17 per cent sugar.

The averages of the analyses of the two varieties from Steuben county are given below:

	Kleinwanzlebener. Average of 8 samples.	Vilmorin. 1 sample.
Per cent solids in juice...	18.90	18.80
Per cent sugar in juice...	16.20	15.90
Per cent sugar in beet ...	15.39	15.11
Per cent purity..........	85.70	84.50

These samples were all grown upon light sandy and gravelly loams.

Tompkins—Eighty-three samples were received at the laboratory of which 61 samples came from the Cornell University Experiment Station plats.

Of the two leading varieties the following samples were received; 67 Kleinwanzlebener and 6 Vilmorin, 10 samples consisted of miscellaneous varieties.

The Kleinwanzlebener and Vilmorin ranged in quality as follows:

Below 12 per cent sugar in beet, 2 Kleinwanzlebener; from

12–13 per cent, 5 Kleinwanzlebener, 1 Vilmorin; from 13–14 per cent, 13 Kleinwanzlebener, 2 Vilmorin; from 14–15 per cent, 9 Kleinwanzlebener, 2 Vilmorin; from 15–17 per cent, 33 Kleinwanzlebener, 1 Vilmorin; above 17 per cent, 5 Kleinwanzlebener. The averages of the analyses of these two varieties are as follows:

	Kleinwanzlebener. Average of 67 samples.	Vilmorin. Average of 6 samples.
Per cent solids in juice...	18.70	18.10
Per cent sugar in juice...	15.79	15.01
Per cent sugar in beet....	15.00	14.26
Per cent purity..........	84.40	82.90

Samples in Tompkins county were grown mostly on clay loam.

Tioga—Twelve samples were received consisting of 3 named and one unnamed varieties. The averages of the analyses are here given.

	Kleinwanzlebener. Average of 4 samples.	Vilmorin. Average of 3 samples.	Schreiber's German. Average of 2 samples.	Unnamed. 1 sample.
Per cent solids in juice	15.80	17.50	17.70	18.90
Per cent sugar in juice.	12.74	14.33	14.95	15.67
Per cent sugar in beet..	12.10	13.61	14.20	14.89
Per cent purity........	80.60	81.90	84.40	82.90

Wyoming—Five samples were received consisting of 1 Kleinwanzlebener and 4 Vilmorin.

The averages of the analyses of the two varieties are as follows:

	Kleinwanzlebener. 1 sample.	Vilmorin. Average of 4 samples.
Per cent solids in juice...	19.90	17.90
Per cent sugar in juice...	17.15	14.69
Per cent sugar in beet....	16.19	13.96
Per cent purity	86.20	82.10

New York State Weather Conditions, from April 1st to October 31st, 1897, compared with those of the corresponding months for 1898.*

APRIL, '97—There was a slight increase over the normal rainfall for most of the state. Temperature 1.3 degrees above the normal.

APRIL, '98—The average rainfall for the state was 0.25 inches above the normal amount. Temperature 1.0 degrees below the normal.

MAY, '97—Decidedly more than the normal rainfall. Temperature averaged 0.8 degrees below the normal.

MAY, '98—The average rainfall for the state was 0.86 inches above the normal. Temperature very nearly normal.

JUNE, '97—Very nearly normal rainfall. Temperature 4.1 degrees below the normal.

JUNE, '98—The average rainfall for the state was 0.72 inches below the normal. Temperature 1.0 degrees above normal.

JULY, '97—Extremely wet, having 3.26 inches more than normal rainfall. Temperature 2.4 degrees above the normal.

JULY, '98—Rather dry, having 1.03 inches below the normal rainfall. Temperature 2.4 degrees above the normal.

AUGUST, '97—Slightly below the normal rainfall. Temperature averaged 1.7 degrees below normal.

AUGUST, '98—Extremely wet, having 2.34 inches more than normal rainfall. Temperature 2.5 degrees above the normal.

SEPTEMBER, '97—Dry, 1.37 inches below the normal rainfall. Temperature 0.1 degree below normal.

SEPTEMBER, '98—The average rainfall for the state was 0.41 inches below the normal. Temperature 3.2 degrees above normal.

OCTOBER, '97—Exceedingly dry, 2.45 inches below the normal rainfall. Temperature 2.8 degrees above the normal.

OCTOBER, '98—Very wet, the rainfall being 1.50 inches above the normal. Temperature 2.8 degrees above the normal.

The following table gives the rainfall for each month, April to October inclusive, in those counties that have grown sugar beets and have had analyses made at the Cornell Experiment Station in 1897. In 1898 fifteen of these counties again grew beets for the Station. If there are two or more *Signal Stations* in a county reporting rainfall, then the average rainfall of the several stations is given.

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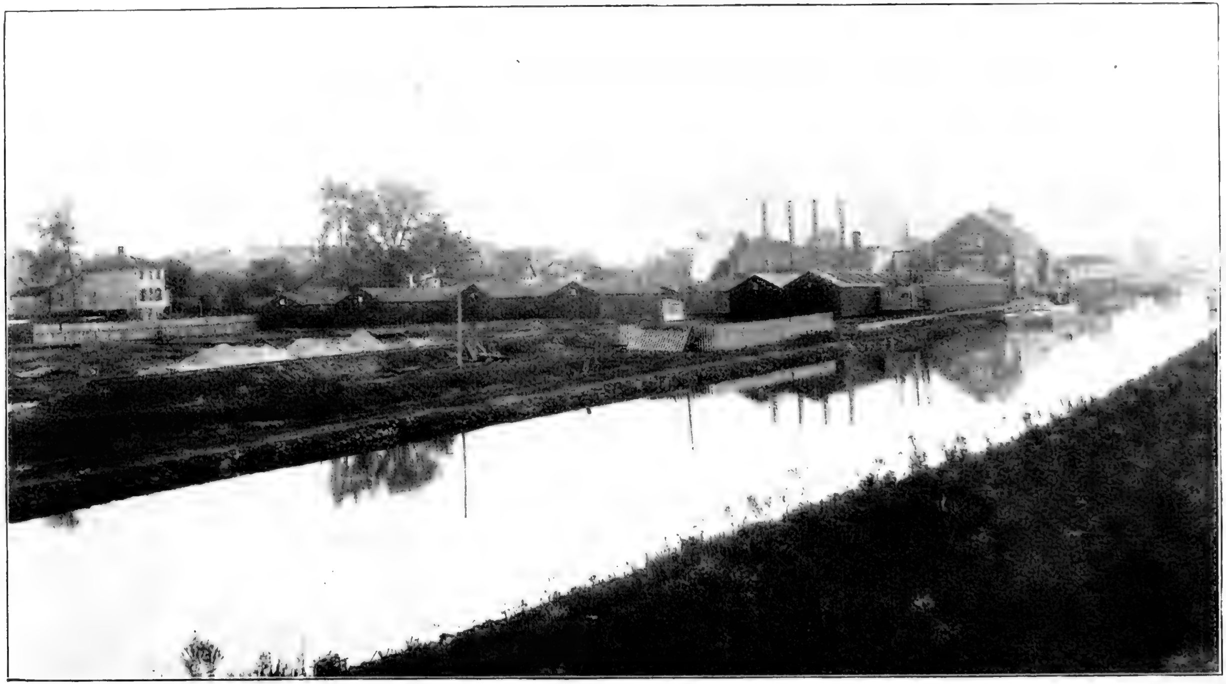
*Condensed from the New York State Weather Bureau Report, Central Office at Cornell University. Professor E. A. Fuertes, Director, Ithaca, N. Y.

PRECIPITATION IN INCHES, 1897 AND 1898 COMPARED BY MONTHS.

	COUNTY.	April, 1897.	April, 1898.	May, 1897.	May, 1898.	June, 1897.	June, 1898.	July, 1897.	July, 1898.	Aug., 1897.	Aug., 1898.	Sept., 1897.	Sept., 1898.	Oct., 1897.	Oct., 1898.
1	Albany........	3.12	2.63	4.69	4.07	4.45	5.58	6.67	1.07	**4.43**	**6.67**	**1.87**	**1.61**	**1.01**	**4.29**
2	Broome	2.16	3.20	4.45	3.79	3.35	2.46	2.42	2.12	**1.61**	**7.42**	**3.30**	**2.55**	**0.74**	**5.39**
3	Cattaraugus. . .	2.08	3.00	3.62	4.09	2.71	5.89	6.83	3.63	**2.63**	**8.06**	**1.25**	**2.87**	**0.56**	**5.75**
4	Cayuga........	2.34	2.60	2.92	3.86	3.93	3.30	4.11	1.93	**2.26**	**5.65**	**3.27**	**4.12**	**1.31**	**4.91**
5	Chautauqua ...	3.29	3.08	3.65	4.61	2.32	5.56	6.79	2.57	**3.55**	**4.71**	**0.81**	**2.26**	**1.56**	**5.14**
6	Erie	2.18	1.73	2.72	2.19	1.87	2.24	6.16	1.72	**1.93**	**2.77**	**0.47**	**3.39**	**1.07**	**3.98**
7	Genesee*	1.87	1.62	2.45	2.23	1.85	3.00	4.54	2.20	**1.49**	**4.88**	**0.84**	**3.48**	**1.04**	**3.99**
8	Herkimer......	3.99	3.77	4.73	4.40	5.47	4.40	5.00	2.72	**2.98**	**9.51**	**1.88**	**3.73**	**1.38**	**4.03**
9	Jefferson	2.16	1.75	3.74	2.98	2.05	2.58	8.22	1.37	**3.54**	**4.35**	**0.78**	**3.65**	**0.42**	**3.80**
10	Livingston	1.66	2.37	2.15	3.45	2.03	4.11	3.14	2.18	**0.55**	**5.57**	**1.21**	**2.29**	**0.66**	**3.83**
11	Monroe........	2.10	1.80	1.94	3.20	2.65	0.98	6.10	1.54	**1.46**	**4.61**	**0.77**	**3.68**	**0.92**	**3.69**
12	Montgomery...	1.93	2.45	4.10	3.71	4.91	3.35	5.58	4.26	**3.13**	**6.14**	**1.89**	**2.77**	**0.84**	**5.46**
13	Niagara	2.52	1.58	2.87	2.29	1.79	2.88	5.68	1.49	**1.54**	**3.43**	**0.93**	**4.85**	**1.06**	**4.15**
14	Oneida	3.36	3.83	4.12	4.35	4.87	4.16	4.92	4.09	**2.71**	**8.15**	**2.30**	**4.65**	**0.38**	**4.79**
15	Onondaga	2.67	2.23	2.77	3.84	3.19	2.14	5.44	1.55	**2.36**	**6.70**	**1.97**	**3.98**	**0.80**	**3.89**
16	Orleans........	2.62	1.49	2.77	2.03	1.77	2.67	5.07	1.35	**2.08**	**3.71**	**0.38**	**3.58**	**1.01**	**3.31**
17	Oswego.	2.19	2.05	2.60	3.88	3.67	1.61	3.98	2.51	**2.42**	**3.82**	**1.09**	**4.18**	**0.57**	**4.84**
18	Saratoga	3.68	3.07	6.35	4.81	6.63	3.16	8.83	2.43	**4.70**	**8.03**	**1.65**	**3.13**	**1.45**	**5.05**
19	Schuyler	2.64	3.28	3.00	3.38	3.00	3.09	3.27	2.65	**2.19**	**4.70**	**2.66**	**1.99**	**0.71**	**6.11**
20	Seneca	2.53	3.60	4.80	4.31	2.71	3.42	4.14	2.42	**0.78**	**4.97**	**3.95**	**2.03**	**1.21**	**8.19**
21	Steuben	2.55	2.87	3.54	3.56	2.56	3.70	6.30	3.13	**2.49**	**4.49**	**2.51**	**1.83**	**0.96**	**5.41**
22	Tioga	2.95	3.76	3.98	4.56	3.59	3.07	4.32	2.99	**3.19**	**7.05**	**4.05**	**2.26**	**0.56**	**6.06**
23	Tompkins	2.65	3.58	3.90	4.07	3.65	2.76	3.78	4.88	**2.48**	**4.95**	**4.59**	**3.05**	**0.94**	**5.04**
24	Wayne	2.33	2.16	1.98	3.60	3.85	2.06	4.44	2.51	**1.19**	**5.58**	**1.15**	**3.21**	**0.62**	**4.66**
25	Yates	......	2.23	......	2.66	......	3.35	.....	2.08	**1.28**	**4.16**	**1.90**	**1.38**	**0.62**	**5.53**

* No report sent in, so the rainfall given is the average for Signal Stations at Ridgeway, Avon and Akron.



76.—*Factory of the First New York Beet Sugar Co. at Rome.*

The Following Bulletins are Available for Distribution to Those Who may Desire Them.

40 Removing Tassels from Corn, 9 pp.
41 Steam and Hot-Water for Heating Greenhouses, 26 pages.
49 Sundry Investigations of 1892, 56 pp.
53 Œdema of the Tomato, 34 pp.
55 Greenhouse Notes, 31 pp.
61 Sundry Investigations of the Year 1893, 54 pp.
64 On Certain Grass-Eating Insects, 58 pp.
69 Hints on the Planting of Orchards, 16 pp.
71 Apricot Growing in Western New York, 26 pp.
72 The Cultivation of Orchards, 22 pp.
73 Leaf Curl and Plum Pockets, 40 pp.
74 Impressions of the Peach Industry in N. Y., 28 pp.
75 Peach Yellows, 20 pp.
76 Some Grape Troubles in Western N.Y., 116 pp.
77 The Grafting of Grapes, 22 pp.
78 The Cabbage Root Maggot, 99 pp.
79 Varieties of Strawberry Leaf Blight, 26 pp.
80 The Quince in Western N. Y., 27 pp.
82 Experiments with Tuberculin, 20 pp.
84 The Recent Apple Failures in N.Y., 24 pp.
87 Dwarf Lima Beans, 24 pp.
92 Feeding Fat to Cows, 15 pp.
93 Cigar-Case-Bearer, 20 pp.
95 Winter Muskmelons, 20 pp.
96 Forcing House Miscellanies, 43 pp.
97 Entomogenous Fungi, 42 pp.
101 The Spraying of Trees and the Canker Worm, 24 pp.
102 General Observations in Care of Fruit Trees, 26 pp.
103 Soil Depletion in Respect to the Care of Fruit Trees, 21 pp.
104 Climbing Cutworms in Western N. Y. 51 pp.
105 Test of Cream Separators, 18 pp.
106 Revised Opinion of the Japanese Plums, 30 pp.
109 Geological History of the Chautauqua Grape Belt, 36 pp.
110 Extension Work in Horticulture, 42 pp
114 Spraying Calendar.
116 Dwarf Apples, 31 pp.
117 Fruit Brevities, 50 pp.
119 Texture of the Soil, 8 pp.
120 Moisture of the Soil and Its Conservation, 24 pp.
121 Suggestions in Planting Shrubbery,
122 Second Report upon Extension Work in Horticulture, 36 pp.
123 Green Fruit Worms, 17 pp.
124 The Pistol-Case-Bearer in Western New York, 18 pp.
125 A Disease of Currant Canes, 20 pp.
126 The Currant-Stem Girdler and Raspberry-Cane Maggot, 22 pp.
127 A Second Account of Sweet Peas, 35 pp.
128 A Talk about Dahlias, 40 pp.
129 How to Conduct Field Experiments with Fertilizers, 11 pp.
130 Potato Culture, 15 pp.
131 Notes upon Plums for Western New York, 31 pp.
132 Notes upon Celery, 34 pp.
133 The Army-Worm in New York, 28 pp.
134 Strawberries under Glass, 10 pp.
135 Forage Crops, 28 pp
136 Chrysanthemums, 24 pp.
137 Agricultural Extension Work, sketch of its Origin and Progress, 11 pp.
138. Studies and Illustrations of Mushrooms: I. 32 pp.
139. Third Report upon Japanese Plums 16 pp.
140. Second Report on Potato Culture. 24 pp.
141. Powdered Soap as a Cause of Death Among Swill-Fed Hogs. 12 pp.
142. The Codling-Moth. 72 pp.
143. Sugar Beet Investigations. 88 pp.
144. Suggestions on Spraying and on the San José Scale. 20 pp.
145. Some Important Pear Diseases. 36 pp.
146. Fourth Report of Progress on Extension Work. 28 pp.
147. Fourth Report upon Chrysanthemums. 36 pp.
148. The Quince Curculio. 28 pp.
149. Some Spraying Mixtures. 8 pp.

Bulletins Issued Since the Close of the Fiscal Year June 30, 1898

150. Tuberculosis in Cattle and its Control.
151. Gravity or Dilution Separators.
152. Studies in Milk Secretion.
153. Impressions of Fruit-Growing Industries.
154. Table for Computing Rations for Farm Animals.
155. Second Report on the San José Scale.
156. Third Report on Potato Culture.
157. Grape-vine Flea-beetle.
158. Source of Gas and Taint Producing Bacteria in Cheese Curd.
159. An Effort to Help the Farmer.
160. Hints on Rural School Grounds.
161. Annual Flowers.
162. The Period of Gestation in Cows.
163. Three Important Fungous Diseases of the Sugar Beet.
164. Peach Leaf-Curl.
165. Ropiness in Milk and Cream.
166. Sugar Beet Investigations for 1898.

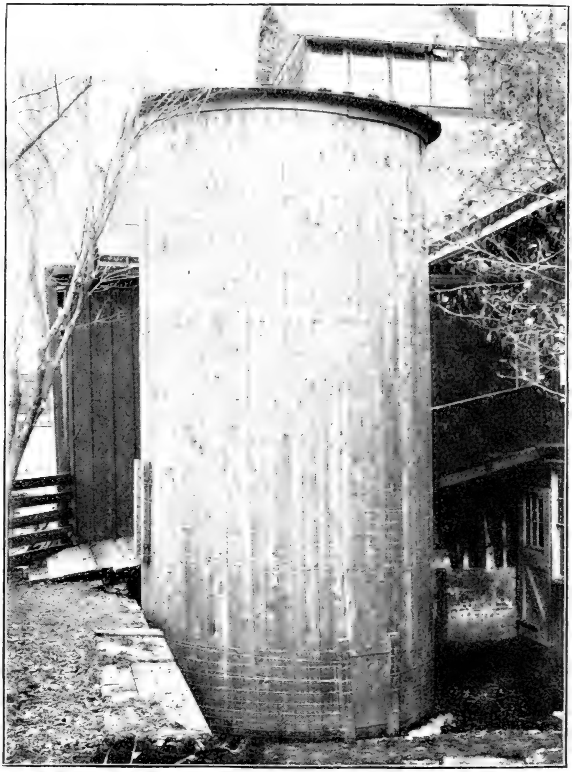
Bulletin 167. **March, 1899.**

Cornell University Agricultural Experiment Station,

ITHACA, N. Y.

AGRICULTURAL DIVISION.

The Construction of the Stave Silo.



By L. A. CLINTON.

PUBLISHED BY THE UNIVERSITY.

ITHACA, N. Y.

1899

Office of Director, Room 20, Morrill Hall.

The regular bulletins of the Station are sent free to all who request them.

CORNELL UNIVERSITY, March 21, 1899.

HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY, N. Y.

Sir: As the dairy industry of the state is developed it becomes of more importance each year that the capacity of the farms to sustain stock be not only maintained, but increased. If the capacity is to be increased, there must be provided some means for storing the roughage or fodder produced on the farm. Of the various forms of roughage, there are none which compare in cheapness of production and value of product, with Indian corn or maize. This crop is becoming the mainstay of the dairy farmer. The question which he has been called upon to decide, is, how this product may be most economically stored. Of all the methods which have been suggested, the ensilaging of corn seems to most fully preserve its original feeding value. Hitherto, the draw-back to this method of storage, has been the imperfection of silos. With the old square or rectangular forms of construction the percentage of waste has been so great that many farmers have hesitated to construct silos. For more than three years we have been carefully studying the points of merit of the stave silo, and it seems to overcome almost entirely the objections which have been made against the square and rectangular forms. As the demand for information with reference to the construction of the stave silo has increased each year it has been thought wise to publish in bulletin form, information as to details of construction. This information is, therefore, offered for publication as a bulletin under Chapter 67, Laws of 1898.

I. P. ROBERTS, Director.

THE STAVE SILO.

The value of good silage has become so generally recognized that it is unnecessary to enter into any discussion on that point. Especially to the dairy farmer has the silo become an almost necessary adjunct to the equipment of the farm. Dr. W. H. Jordan, Director of the New York State Experiment Station, Geneva, N. Y., in an address before the N. Y. State Dairymen's Convention in 1897 said, "Silage properly made and properly fed never yet injured a pound of milk."

The trouble with much of the silage fed, is that it fails to comply with one or the other and frequently both of the above conditions. One cause which has contributed more than any other toward poor silage has been faulty construction of the silo. No matter how good the corn when ensilaged nor how carefully and intelligently the silage may be fed, if the silo is so constructed that a moldy, sour product results, satisfactory returns from feeding cannot be secured. Reasons frequently offered as an excuse by farmers for not having a silo are the facts that the percentage of loss is usually considerable and the original cost of the silo is beyond their means. The stave silo more nearly overcomes these objections than any other form of silo which has been proposed. The important features which must be possessed by a silo to adapt it to the needs of the masses are, first, ability to preserve the silage; second, cheapness and simplicity of construction; third, durability.

After making for three years careful study and observation of the stave silo we believe it meets fully the above requirements, and that it is the most practical and successful silo which can be constructed. The round stave silo presents no corners which may pull apart and admit air, and which cause the silage to settle unequally; the original cost is very slight as no expert labor is required, all mason and carpenter work can be done by the usual farm help. The material used in construction is the minimum

amount for obtaining the maximum capacity; the durability of the stave silo is as yet only a matter of conjecture for decay has not commenced on any stave silo which we have examined.

A stave silo built at Cornell University in 1898, has a part of the staves of hemlock, a part of Georgia pine, part of white pine and part of cypress. These different materials will be carefully observed in future years to determine their relative value.

As many letters of inquiry have been received during the past year asking for information about silos and details for the construction of the stave silo it has been thought wise to publish a bulletin which should give somewhat fully the information called for.

The location of the silo.—A silo should be located with reference to facility in feeding. This condition is important above all others. If stock are housed in the basement it is well to have the bottom of the silo on a level with the floor of the basement. It is cheaper to elevate the silage at the time of filling the silo when it can be done on a carrier by steam power, than to elevate it in baskets at time of feeding when it must usually be done by man power. The practice of digging pits into which to put the silage is not to be commended as it causes an unnecessary expense at the outset and is afterwards a source of extra labor and annoyance when the silage is fed.

Whether the silo shall be placed on the interior or exterior of the barn must be determined for each individual case. If at the time the barn is planned arrangements are made for the silo it can nearly always be placed on the interior. If, however, it is desired to erect a silo and the barn is already constructed it is usually more convenient to place the silo on the exterior. It is very largely a matter of economizing space and labor. If placed inside the barn no extra expense need be incurred for roofing, the work is concentrated and it will usually be found more convenient than placing the silo on the outside. Some caution must be observed especially if the silo is located near the milking room and the silage should not be thrown down until the milk is removed from the range of its odor. Wherever the silo is located it should be with reference to economizing labor in feeding and it should be placed at the point most convenient

regardless of any slight extra expense which may be incurred by so doing.

Size of silo to construct.—In calculating the amount of silage which will likely be needed, it is customary to estimate that a 1000 pound cow will consume about 40 pounds or one cubic foot of silage per day. This gives a basis upon which to calculate the capacity of the silo required to carry a certain amount of stock One cow to be fed a full ration of silage, say from November 1st to May 1st, would require 7,240 pounds which would necessitate a storage capacity in the silo of 181 cubic feet. If, say 20 cows are to be fed during the period above mentioned there would be required 144,800 pounds of silage necessitating a storage capacity in the silo of 3,620 cubic feet. It frequently becomes a question of considerable importance to know how large a silo should be constructed in order to furnish the necessary storage room. The following table showing the approximate capacity, in tons, of silos of various depths and diameters, may be found useful.

Table showing approximate total capacity of cylindrical silos for well matured corn silage, in tons.

Depth. Feet.	Inside Diameter in feet.										
	12	15	16	17	18	19	20	21	22	23	24
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
20	45	70	80	90	101	113	125	138	151	167	180
21	47	74	84	95	106	118	132	145	159	173	190
22	49	77	88	99	111	124	138	152	166	182	198
23	52	81	92	104	117	130	144	159	174	190	207
24	54	84	96	108	122	135	150	166	179	199	216
25	56	88	100	113	127	141	157	173	189	207	225
26	59	92	104	118	132	147	163	180	197	215	235
27	61	95	108	122	137	153	169	187	205	224	244
28	63	98	112	126	142	158	175	193	212	232	252
29	65	101	116	131	147	164	182	200	220	240	262
30	67	105	120	136	152	170	188	207	227	249	271

In making out the above table the mean weight of a cubic foot of well settled silage has been taken as 40 pounds. While this is only an approximation, yet it comes near enough to enable us to estimate the capacity of silos. It is known that in

the upper part of a silo 24 feet deep, a cubic foot of silage will not weigh more than 35 to 38 pounds, while in the lower part the weight will run from 40 to 45 pounds. At Cornell University a silo 24 feet deep was filled with well matured corn during the latter part of September 1898. After allowing it to settle for four or five days it was filled again to the top. This was repeated three times, the silo being filled to the top each time after it had been allowed to settle. It was finally covered over with about one foot of freshly cut second growth clover. When the silo was opened in November the silage had settled so that the top of it was five feet below the top of silo. On the 25th day of February 1899 several samples each consisting of one cubic foot of settled silage were weighed. These samples were taken at a depth of 14 feet from the top of the silo and 9 feet below where the top of the settled silage had been. The weight of one cubic foot of silage at the depths above mentioned was found to be 38 pounds.

How to use the above table.—The table given above is to enable one who contemplates constructing a silo to estimate the size of silo which will be needed. From 25 to 30 pounds of silage per cow is regarded as a light daily ration, 35 to 40 pounds as a medium and 40 to 50 as liberal. If it is assumed that 40 pounds of silage or one cubic foot per day, will be about the amount fed per cow, we can then closely estimate the size of silo needed.

The table gives the capacity of silos could they be filled with settled silage. Practically this is never possible. If the silo is filled with well matured corn and then after the silage has settled is filled again and this is repeated two or three times, we can get only about three-fourths the maximum capacity of the silo in settled silage. If the silo is filled but once and is not refilled after the silage has settled, not more than two-thirds the capacity of the silo can be obtained in settled silage. Thus if the silo can be filled in the manner first mentioned one should be constructed which has a maximum capacity one-third greater than for the amount of silage required. If the silo is to be filled rapidly and not refilled after settling, it should have a capacity one-half greater than for the actual amount of silage required.

If, as in the case previously mentioned, 20 cows are to be fed from Nov. 1st to May 1st a period of 181 days there will be consumed 72.4 tons of silage.

If the silo be filled by the first method there will be needed in this case a maximum capacity for 96 tons, which will be nearest met by a silo 24 feet deep and 16 feet in diameter. If the silo is filled according to the second method, there will be needed a maximum capacity for 108 tons, which will be most nearly met by a silo 27 feet deep and 16 feet in diameter. It is always well to construct a silo somewhat larger than the present needs seem to demand. Then as the herd increases or the use of silage increases, extra silo capacity will have been already provided.

Construction of foundation for stave silo.—Where the silo is to be constructed an excavation should be made to a depth of 3 or 4 inches or to the bottom of the loose surface soil and with a diameter at least two feet greater than the proposed diameter of the silo and drainage should be provided if the conditions seem to warrant. The excavation should be filled with stones, large ones being placed at the bottom and smaller ones being worked in and pounded down toward the top. Gravel if well pounded down may serve as filling between the stones. It is important that the pounding be thoroughly done, otherwise settling will take place later on and the cement finish be made to crack.

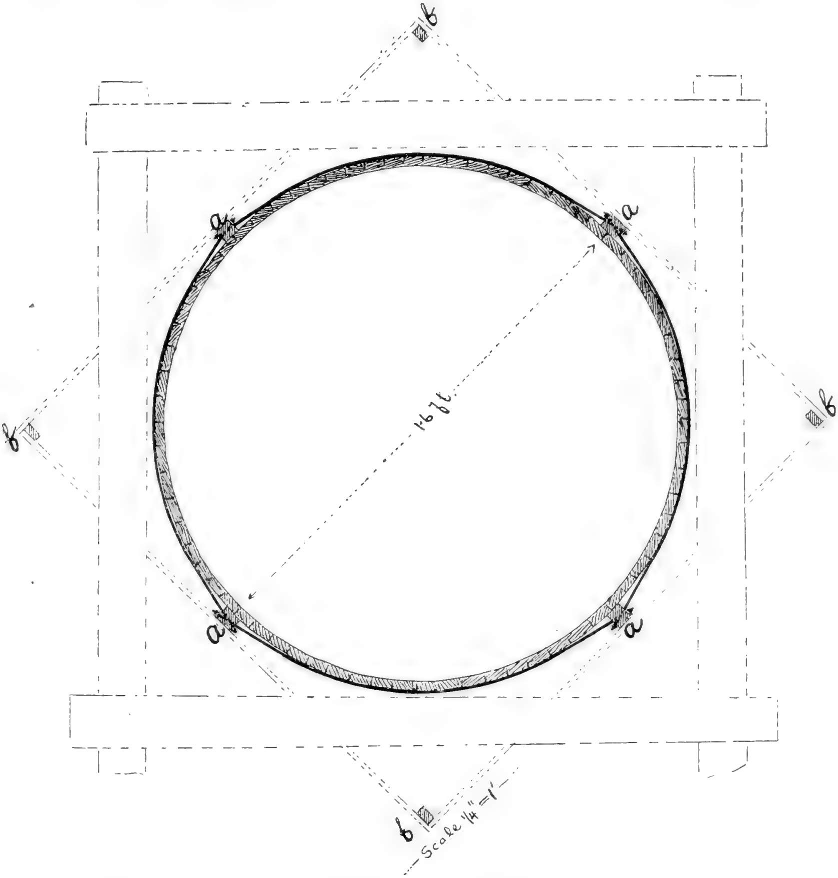
The finishing should be done with cement. First a thin mortar made of one part of Portland or Rosendale cement and four parts of good sharp sand should be poured over the entire stone work. This mortar should be made so thin that it will run down into the interstices between the stones. After this first coat has thoroughly set a finishing coat made of one part cement and three parts of sand should be put on and worked down with a trowel. Finish off before thoroughly dry by dusting over the top some clear cement and working it in with a trowel. This will give a hard finish and will secure a foundation that is cheap and efficient. While the cement is still soft it is frequently convenient to strike the circle which will mark the line upon which the staves are to be set. A spike driven in the center will serve as a pivot. Attach to this a bit of string or twine the length of which shall be one-half that of the proposed diameter of the silo and to the free end of the string fasten some pointed instrument with which to mark the circle. Now strike a circle the radius of which shall be equal to the length of the string and there is marked out the circle upon which the staves are to be set.

Material to use for staves.—It is probable that no better material can be obtained for the staves than Southern cypress. This, however, is so expensive in New York State as to preclude its use in most cases. Of the cheaper materials hemlock, white-pine, and yellow-pine are usually the most available. At the present time hemlock is one of the cheapest satisfactory materials which can be purchased and it is probably as good as any of the cheaper materials. It should be sound and free from loose knots.

Preparation of the staves for the silo.—If the silo is to have a diameter of 12 feet or less the staves should be made of either 2 x 4 material unbevelled on the edges and neither tongued nor grooved, or of 2 x 6 material bevelled slightly on the edges to make the staves conform to the circular shape of the silo. If the silo is to have a diameter of more than 12 feet the staves should be of 2 x 6 material and neither bevelled nor tongued and grooved on the edges. If the staves are left perfectly plain, then when they are set in place and drawn together the first point of contact will be the inner edge and the tighter the hoops are drawn the closer will become the contact of the staves at the inner edge. If it is impossible to purchase material for staves the length of which shall be equal to the desired depth of the silo then shorter staves may be used and set up according to the method hereafter described. The staves should be surfaced on the inside so that a smooth face may be presented which will facilitate the settling of the silage. Whether the outside of the staves shall be planed is a matter of taste, but if hemlock is used the handling of the staves will be found much easier if both sides are planed.

Setting up the silo.—There are several methods of procedure which may be followed in setting up the silo. Fig. 77 shows a cross section of one method of construction. The posts (a, a, a, a,) should be of 6 x 6 material and run the entire length of the silo. These should be first set up vertically and stayed securely in place and then they may be used as part of the scaffolding, they will also serve to give rigidity to the staves as the work of setting up progresses, and when the roof is put on, the plates which support the roof may be laid on these posts. The scaffolding may be constructed by setting up 2 x 4 scantling in the positions shown in

fig. 77 as *b b b b*. Boards nailed from these 2 x 4 scantling and to the 6 x 6 posts will form a rigid frame work across which the planks for the scaffold platform may be laid. Before the scaffolding is



77.—*Shows cross section of stave silo, the dotted lines are to show how scaffolding may be put up.*

all in place the staves should be stood up within the inclosure, otherwise difficulty will be experienced in getting them into position. Some caution needs to be exercised in working on the scaffolding that the planks do not tip, but with ordinary care there need be no danger. The first stave set up should be made

plumb and should be toe-nailed at the top to one of the posts originally set.

If one man works at the top of the staves and one at the bottom with another man to assist in raising them in position they may be set up very rapidly. Immediately a stave is set in place it should be toe-nailed at the top to the preceding stave set. It has been found that the work of setting up and preserving the circular outline may be materially aided by the use of old barrel staves. For a silo 12 feet in diameter the curve in the stave of the sugar barrel is best adapted, for a 16 foot silo the flour barrel stave is best and for a silo 20 feet or more in diameter the stave of the cement barrel is best. Before commencing to set up the silo there should be at hand an abundance of old barrel staves of the kind best adapted to the work as designated above. When a silo stave is set in place nail to it horizontally and on the inside a barrel stave. One barrel stave will reach across several of the silo staves and should be secured by shingle nails to each silo stave. One row of barrel staves should be nailed on or near the top and one near or below the middle. These barrel staves assist in keeping the silo on the proper curve and do away with the necessity of making a mold or form. Fig. 78 shows how the barrel staves are used. If when the silo staves are put in place they are toe-nailed securely to the ones previously set; if they are fastened firmly to the permanent upright posts (a, a, a, a fig. 77); if the barrel staves are used as directed above, the silo will have sufficient rigidity to stand

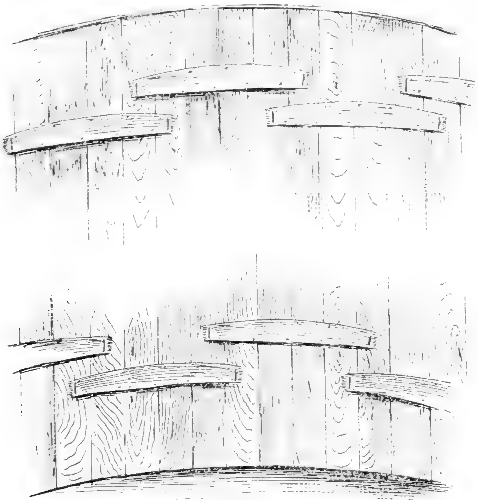


FIG. 78.—*Shows how barrel staves may be used in setting up a silo, they should be removed before the silo is filled.*

until the hoops are put in place. However, if it becomes necessary for any reason to delay for any considerable time the putting on of the hoops, boards should be nailed across the top of the silo. These will serve as braces and will enable the silo to resist wind storms of considerable violence without collapsing. As the staves are set up the level or plumb should be used occasionally to determine if they are being set vertically. The 6 x 6 posts mentioned as being first to be set in place are not a necessity, they are a convenience. Where a silo is being erected away from any other building these posts furnish the fixed points and assist in giving stability to the structure. When the roof is put on they will also be found of material benefit. If the silo is set up inside of the barn or in close proximity to the barn or other building, the first staves set up may be braced from the building. After a few staves are in place plank may be nailed across the top and thus a platform secured upon which a man can work. Unless some better method for securing the scaffolding can be devised the use of the uprights as shown in fig. 77 will be found valuable.

Splicing the staves.—If it is desired to build a silo 24 to 30 feet or more in height, it will often be found impracticable if not impossible, to secure staves the full length desired. Where this is the case a joint or splice may be made. For a silo 30 feet deep staves 20 feet in length may be used. A part of these should be used at their full length and part should be sawed through the middle, thus making staves of 20 and 10 feet length. In setting them up the ends which meet at the splice should be squared and toe nailed securely together. They should alternate so that first a long stave is at the bottom then a short one, thus breaking joints at 10 feet and 20 feet from the base. This breaking joints is preferable to having the joint come in a circle entirely around the silo, as it gives additional strength. Care needs to be exercised that the ends are made square, otherwise the air will be admitted.

Hoops for the stave silo.—The hoops for the stave silo are usually made from five-eighths inch round iron or steel rods. Cheaper substitutes have been used and given good satisfaction. The frontispiece shows a silo erected at Cornell University in which common woven wire fencing was made to serve as hoops. When

the large stave silo inside the barn was filled it was found that more room was needed in which to store the corn crop. This was obtained by constructing a small silo 24 feet high and 12 feet in diameter, which was set up in a day and hoops of fence wire were put on and secured as shown in frontispiece. The staves were of 2x6 hemlock, 24 feet long, with edges neither matched nor bevelled. The silo was filled directly after completion and was satisfactory in every way.

Where the round hoops are used it is well to have each hoop in from three to four sections. For a silo 12 feet in diameter three sections will be sufficient, while for a silo 16 feet or more in diameter the hoops will handle more conveniently if they are in four sections each. If the method of construction shown in figure 77 is followed, then the hoops will need to be in four sections each, the ends being passed through the upright 6x6 posts and secured by heavy washers and nuts. A chisel should be used to sink one edge of the washer slightly so that the

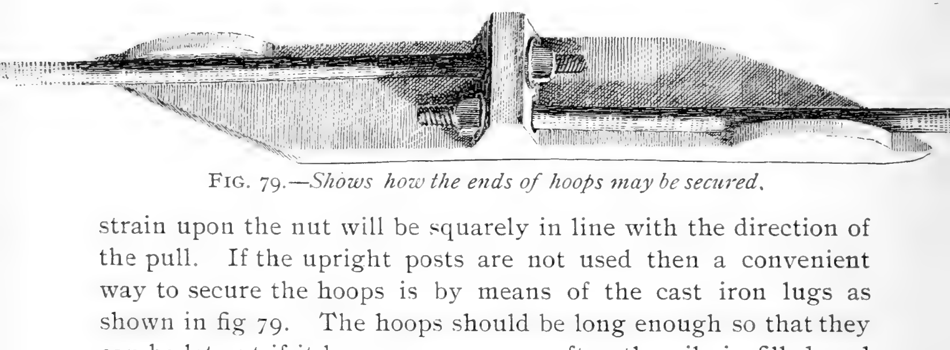


FIG. 79.—*Shows how the ends of hoops may be secured.*

strain upon the nut will be squarely in line with the direction of the pull. If the upright posts are not used then a convenient way to secure the hoops is by means of the cast iron lugs as shown in fig 79. The hoops should be long enough so that they can be let out if it becomes necessary after the silo is filled and the strain becomes great. If when the hoops are tightened it is found that the thread at the end has not been made sufficiently long, pieces of gas pipe may be used as washers with which to take up the slack.

The bottom hoop should be about six inches from the base of the silo; the second hoop should be not more than two feet from the first; the third hoop two and one-half feet from the second, the distance between hoops being increased by one-half foot until they are three and one-half feet apart, which distance should be

maintained except for the hoops at the top of the silo which may be four feet apart. The hoops should be drawn fairly tight before the silo is filled but not perfectly tight. They must be tight enough to close up the space between the staves thus preventing any foreign matter from getting into the cracks which would prevent the staves from closing up as they swell, thus allowing air to enter. To hold both the hoops and the staves in place during the summer when the silo is empty, staples should be driven over the hoops into the staves. If a sufficient number of staples are used they will prevent the sagging or dropping down of the hoops and they will hold the staves securely in place.

The hoops should be watched very closely for a few days after the silo is filled. If the strain becomes quite intense the nuts should be slightly loosened. If during the summer when the silo is empty and the staves thoroughly dry the hoops are tightened so that the staves are drawn closely together, when the silo is filled and the wood absorbs moisture and begins to swell, the hoops must be eased somewhat to allow for the expansion. If a silo is constructed of thoroughly seasoned lumber and the hoops are drawn tight before filling, when the silo is filled the hoops must be loosened slightly or there is danger that the hoops will break or the thread will be stripped.

In one case a silo was allowed to dry out in the summer and fall down when by the use of staples or a few minutes spent in tightening the hoops, it might have been prevented. Another silo met with disaster due to the fact that the hoops were drawn perfectly tight on a dry silo and were not loosened when the silo was filled. The result was the hoops broke. A little judgment and care should be exercised with this as with all other farm operations.

Doors for the stave silo.—The doors should be located on the side of the silo most convenient for feeding. They may be in line, one directly above the other or they may be placed anywhere fancy or convenience dictates. If doors are placed one above the other the short pieces of staves should be well secured to the hoops by staples. The lower door should be between the second and third hoops at the bottom and other doors will usually be needed in every second space between there and the top except

that no door will be needed in the top space as the silage when settled will be sufficiently low to enable it to be taken out at the door in the space below. Plans should be made for the doors at the time the staves are set. When the place is reached where it

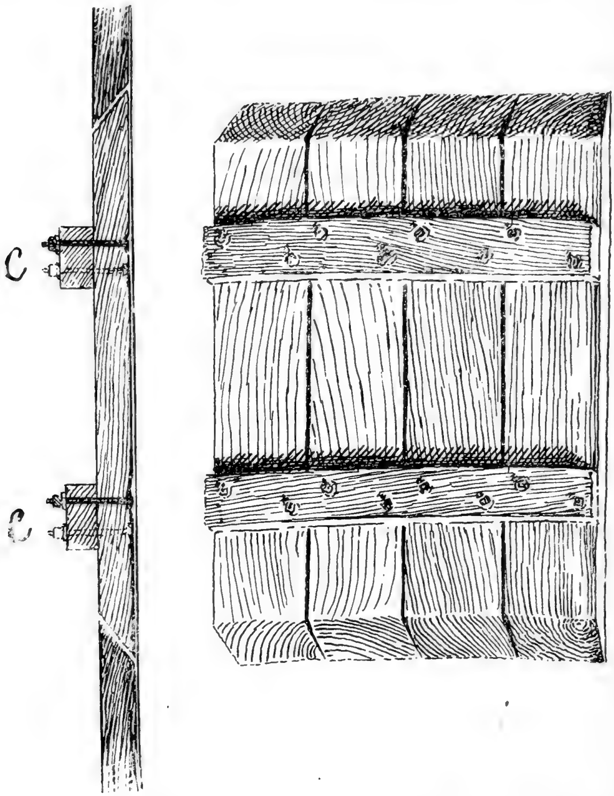


FIG. 80.—*Shows appearance of door after being sawed out, and shows side view of door in place. The cleates c. c. are on outside of door.*

is desired to have the doors, a saw should be started in the edge of the stave at the points where the top and bottom of the doors are to come. The saw should be inserted so that the door can be sawed out on a bevel, making the opening larger on the inside of the silo. (See fig 80.) This will enable the door to be removed and put in place only from the inside and when set in

place and pressed down with silage, the harder the pressure the tighter will the door fit. The sawing into the edge of the stave

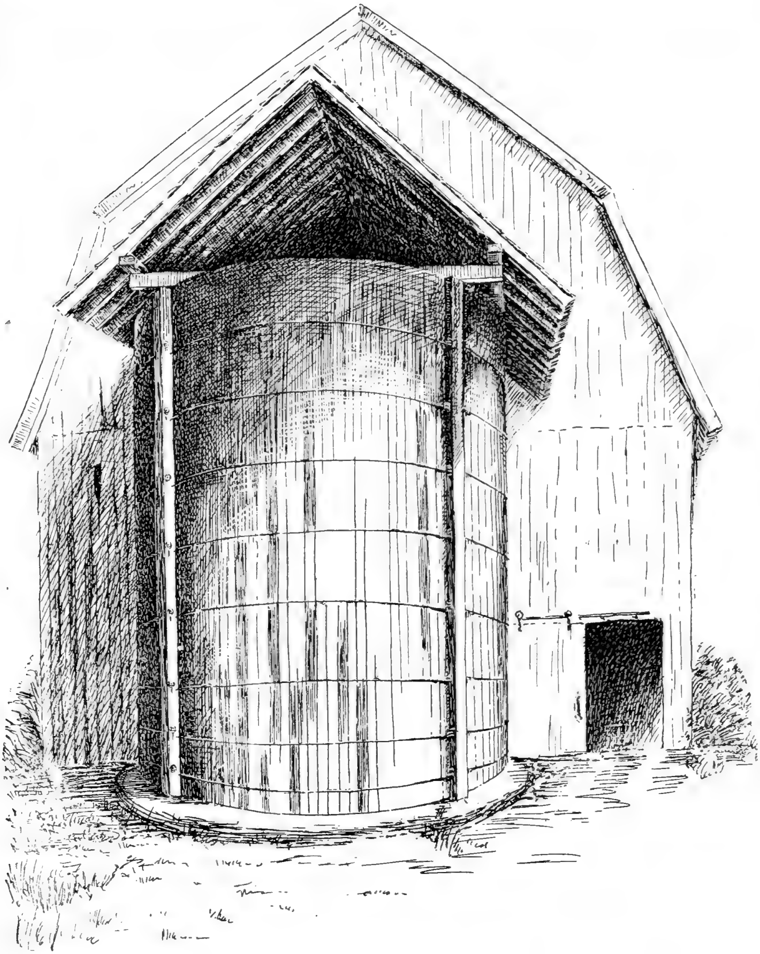


FIG. 81.—*Shows plan of Construction of Stave Silo.*

at this time is to permit the sawing out of the door after the staves are all in place without the necessity of making an auger hole, which would admit the air. After sawing into the edge of the stave deep enough to admit the end of the saw the stave

should be set in place so that the side corresponding to c. c. in fig. 80 shall be on the outside of the silo. After the silo is set up and the hoops have been put on and tightened the cutting out of the doors may be completed. The size of doors would better be two feet wide by about two and one-half feet long. This will allow the passing through of a large basket and will make a door of convenient size for handling. Before cutting out the doors cleats 2 inches by 3 inches and in length equal to the width of the door, should be made which will conform to the circular shape of the silo. One of these cleats should be securely bolted to the top and one to the bottom of where the door is to be cut. (See fig. 80.) After the bolting, the door may be sawed out and it is then ready for use. When set in place at time of filling the silo a piece of tarred paper inserted at the top and bottom will fill the opening made by the saw and prevent the entrance of any air around the door. Two silos built at Cornell University the past year had the doors constructed and put in, in the manner above described and not one pound of silage was wasted around doors.

The silo roof.—If constructed in the barn no roof or covering of any kind will be needed. If constructed out of doors some kind of roof should be provided. If the method of construction shown in fig 77 is followed, and the upright 6x6 posts are used, these posts may serve as supports for the plates upon which the rafters are to rest. The roof should have a sufficiently wide projection to protect as thoroughly as may be the walls of the silo from the elements. The plan of roof construction which will prove efficient is shown in fig 81. It is not necessary that the structure be air tight above the circular part. The gable end which is shown as open in the figure, may be boarded up. In this gable end a door should be provided through which the silo can be filled. The roof should extend from the silo to the barn so as to cover the space which intervenes, and thus afford protection to the feeder in stormy weather. Another way in which the roof may be put on is shown in the frontispiece. Around the top of the silo was bent and nailed one-half inch Georgia pine. This was put on so that a slight slope was given to the roof boards which simply overlap each other. The roof answered every pur-

pose. Another form of roof which is now doing service over a silo 16 feet in diameter by 24 feet deep is shown in fig 82.

This silo was constructed in Tompkins County in the summer of 1898. No roof was put on until after the silo was filled.

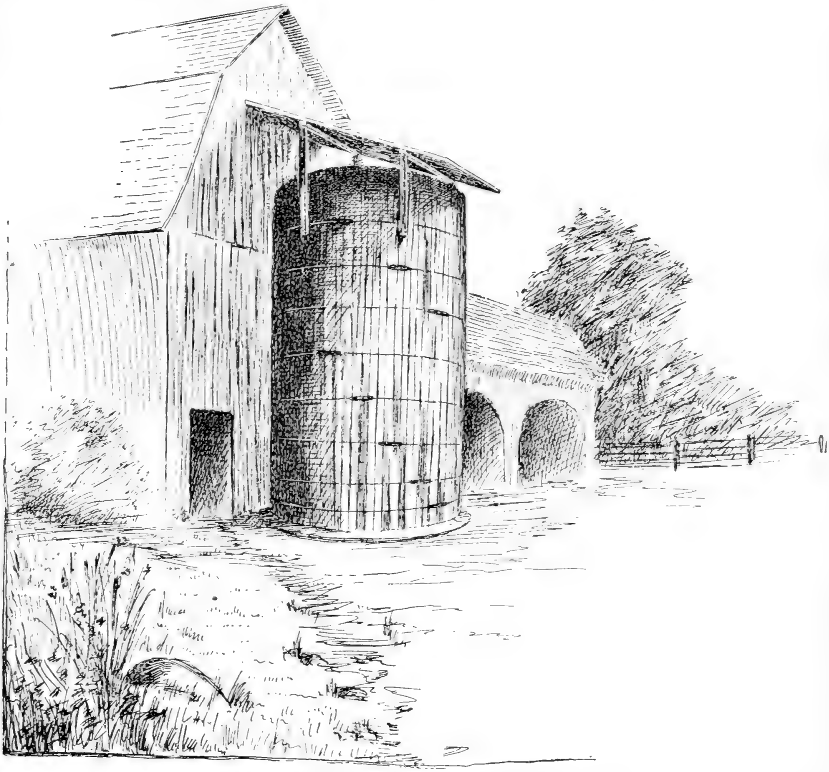


FIG. 82.—*Shows a roof which is doing good service.*

Then pieces of 2 x 4 scantling were nailed to the staves, plates were laid across the top and the roof supported as shown in the figure. The silage in this silo when examined in February directly after the temperature had been at zero for several days, and some of the time as low as 20° below zero, was found to be in most excellent condition. It was frozen around the edge next to the staves, but the frost had not penetrated for more than six inches. The top of the silage had been covered over with a foot

or more of buckwheat straw and this protected the silage from action of frost. Samples of the frozen silage were taken and when thawed out no deterioration in value was observed. When these silos are constructed out of doors it is considered important that in cold weather the top of the silage be well covered over with straw or hay, or some other material which will conserve the heat from the interior. The covering can be pitched back each day as the silage is removed for feeding and then returned to place again. This practice successfully protected silage during the most severe weather that has been experienced in New York for many years.

Painting the silo.—Whether the silo shall be painted on the outside is simply a matter of taste. If the other farm buildings are painted it would be well to have the silo painted the same as the other buildings. Various paints and compounds have been recommended for the interior. Probably the best paint is common gas or coal tar put on hot, though it is very doubtful if the interior is improved by painting. If paint is applied to the staves while they are still green it is likely to hasten rather than prevent decay. If gas tar or paint is applied it should be done after the hoops are made tight and the staves drawn close, otherwise the paint is likely to enter the cracks and harden and thus prevent the staves from being drawn together. The large silo built at Cornell University was painted upon the interior, a part with gas tar and a part with a special preparation, and one part was left with no paint, the silage kept equally well in all portions of the silo.

It is impossible to anticipate all difficulties which will be met with in various cases. Ingenuity and judgment will suggest many changes from the plans which have been outlined above. It is hoped, however, that the suggestions herein contained will be of value to those who contemplate building a silo, and it is possible that the attention of some will be called to the feasibility and value of the silo who have not heretofore given the subject serious thought.

L. A. CLINTON.

Bulletin 168. **May, 1899.**

Cornell University Agricultural Experiment Station.

ITHACA, N. Y.

BOTANICAL DIVISION.

Studies and Illustrations

OF

MUSHROOMS: II.

"By the rose flesh mushrooms, undivulged
Last evening. Nay, in to-day's first dew
Yon sudden coral nipple bulged,
Where a freaked, fawn-colored, flaky crew
Of toadstools peep indulged."
Browning's By the Fireside.

THREE EDIBLE SPECIES OF COPRINUS.

By GEO. F. ATKINSON.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1899.

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CORNELL UNIVERSITY, ITHACA, May 15, 1899.

HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY, N. Y.

Sir: This bulletin, the second of a series of "Studies and Illustrations of Mushrooms," is submitted under Chapter 67 of the Laws of 1898. The object of these studies is to give accurate information upon, and illustrations of, the more common mushrooms or toad-stools. This should enable interested persons to collect and determine specimens occurring from spring to late autumn. Large numbers of the edible species go to waste each year for the want of some clear and ready information to assist in distinguishing the edible from the poisonous kinds.

It is to be regretted that in the smaller cities, in suburban districts, and upon the farms, more attention is not given to learning to know *well* a few of the more common species, since the fields and woods where these plants grow are so easy of access. By careful attention to the localities and by comparison of the plants with the descriptions and illustrations given in these bulletins, a person having no botanical knowledge can identify a number of these plants. Every one has, or should have, a certain amount of leisure time which can be devoted to recreation, or relief from the every day work. Many find enjoyment and profit in combining such recreation with an interest in some observation upon nature and natural objects. Having learned to recognize the edible species, it is possible thereafter to readily collect for food large numbers of the more common ones. Some of these plants are so easily determined that children only eight years old, after seeing the photographs of two of the species illustrated in this bulletin, were able later to name the plants from freshly collected specimens, without the opportunity of a comparison with the photographs.

One not familiar with the subject should use caution in the first collections of an unknown plant. It is well in some cases

to consult some one who does know the plants, or who has the means of determining them. In such cases, the Botanical Division of this Station is ready to assist in the identification. Directions for collecting and mailing specimens are given in the present bulletin. With some attention to this subject there is no reason why, in America, mushrooms should not form as important an article of food as they do in parts of the Old World.

Professor Atkinson has made a large number of photographs of the edible and poisonous mushrooms, as well as of those wood destroying species so destructive to timber and forest trees.

I. P. ROBERTS, Director.

STUDIES AND ILLUSTRATIONS OF MUSHROOMS, II.

Three Edible Species of Coprinus.

I—The Shaggy-Mane (*Coprinus comatus*).

The "shaggy-mane," or "horsetail mushroom" (Coprinus comatus), is one of the largest plants of this genus. It is usually considered by many to surpass all the other species of the genus in those qualities most esteemed by the fungus eater. The frontispiece is from a photograph of a group of these plants growing in a lawn on the Cornell University Campus. All stages of the "horsetail" are here represented, from the tiny ones which are thrusting their heads through the turf to the old ones which present an unsightly aspect as they are melting down into inky blackness, an example of the swiftness with which it passes its ephemeral existence. A day, or at most two or three days is vouchsafed to it during which it is to lift itself up into the free air, where it may expand and mature its spores. Then it vanishes. But it has accomplished the final purpose for which it exists as an organism. Its "seed," the spores are free to be carried by the wind or other agencies of dissemination to distant places, and thus propagate the species. While the natural mode of the wide dissemination of the plant is probably by the distribution of the spores, dissemination may take place through the agency of man or other animals when the soil is disturbed.

Some of the "spawn" may be transplanted in the sod for covering new lawns, or in the fertilizer for old ones. Here food lying hidden in the soil is awaiting forage at the pleasure of the searching threads of the mycelium or "spawn," which now spreads its meshes as it extends through the earth. Here it grows for months or sometimes for years may be, laying by supplies in the shape of an increased amount of "spawn." We tread upon the soft carpet of green or recline on the sod unmind-

ful of the process of growth, absorption and assimilation in that wonderful unseen world of plant life. Suddenly some morning we see the shaggy, unkempt heads of our old friends again just risen from their long sleep which calls to mind Browning's verse,—

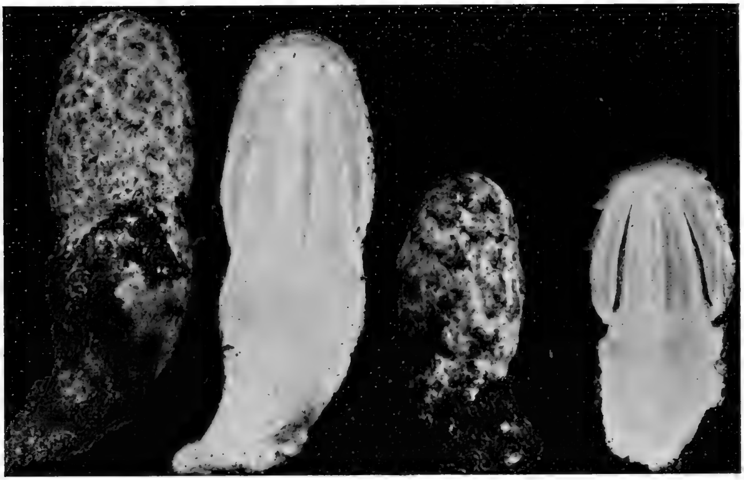
> "By the rose flesh mushrooms undivulged
> Last evening. Nay, in to-day's first dew
> Yon sudden coral nipple bulged,
> Where a freaked, fawn-colored flaky crew
> Of toad-stools peep indulged."

83.—"*Shaggy-mane*" (*Coprinus comatus*) *in lawn.*

A "mushroom growth," we say. It looks that way ; as if the whole thing had grown in a single night. That is because we have not searched underneath the sod and observed the long, tedious process of growth while the cords and meshes of the mycelium have increased, and extended their lines through the moist soil. If we do search there and observe we see that sometime before the shaggy heads peep forth, tiny bodies appear on the cords of mycelium ; first like a pin head in size, then as large as a pea and the size of a thimble they grow. A great deal of

growth has taken place in the formation of these tiny bodies beneath the soil. They are made up of delicate threads and the tiniest cells which have multiplied until there are countless numbers of them. Now when every thing is ready in these fungus "buttons," the tiny cells already formed, as well as new ones still forming, expand rapidly and this pushes the mushroom up into view in a single night.

In figure 84 are shown two buttons of the size when they are just ready to break through the soil. They are now quite dark



84.—"*Buttons*" *of Coprinus; two in section, showing gill slits and hollow stem.* (*Natural size.*)

in color on the outside. They appear mottled with dark and white, for the outer layer of fungus threads, which are dark brown, is torn and separated into patches or scales, showing between, the delicate meshes of white threads which lie beneath. The upper part of the button is already forming the cap or "pileus," and the slight constriction about midway shows the lower boundary or margin of the pileus where it is still connected with the undeveloped stem.

We are curious to know if the internal structure of these buttons will reveal the parts of the mushroom. We can learn this by splitting buttons through from one end to the other with a

sharp knife. At the right of each of these buttons in the figure is shown a section of a plant of the same age. Here the parts of the plant though still undeveloped are quite well marked out. Just underneath the pileus layer are the gills. In the section

85.—*Coprinus comatus, removed from soil.* (*Natural size.*)

one gill is exposed to view on either side. They are long, narrow, and taper at each end. In the section of the larger button the free edge of the gill is still closely applied to the stem, while in

the small one the gills are separated a short distance from the stems showing "gill slits." Here, too, the connection of the margin of the pileus with the stem is still shown. From our first study of mushrooms (Bulletin 138) we know that this connecting layer between the margin of the pileus and stem forms the veil. This kind of a veil is a marginal veil.

86.—*Coprinus comatus, well meriting the name "shaggy mane".* (*Natural size.*)

The stem is hollow even at this young stage, and a slender cord of mycelium extends down the center of the tube thus formed as is shown in the sections. From the button stage the growth is quite rapid, and in a short while the plants are full grown.

Now the plants are nearly all white. The brown scales so close together on the buttons are widely separated except at the top or center of the pileus, where they remain close together and form a broad cap resting jauntily on the shaggy head. This is shown in figure 85 which is from a photograph of three plants removed from the sod.

A study of the different stages, which appear from the button stage to the mature plant, reveals the cause of this change in color and the wide separation of the dark brown scales. The threads of the outer layer of the pileus, and especially those in the brown patches seen on the buttons, soon

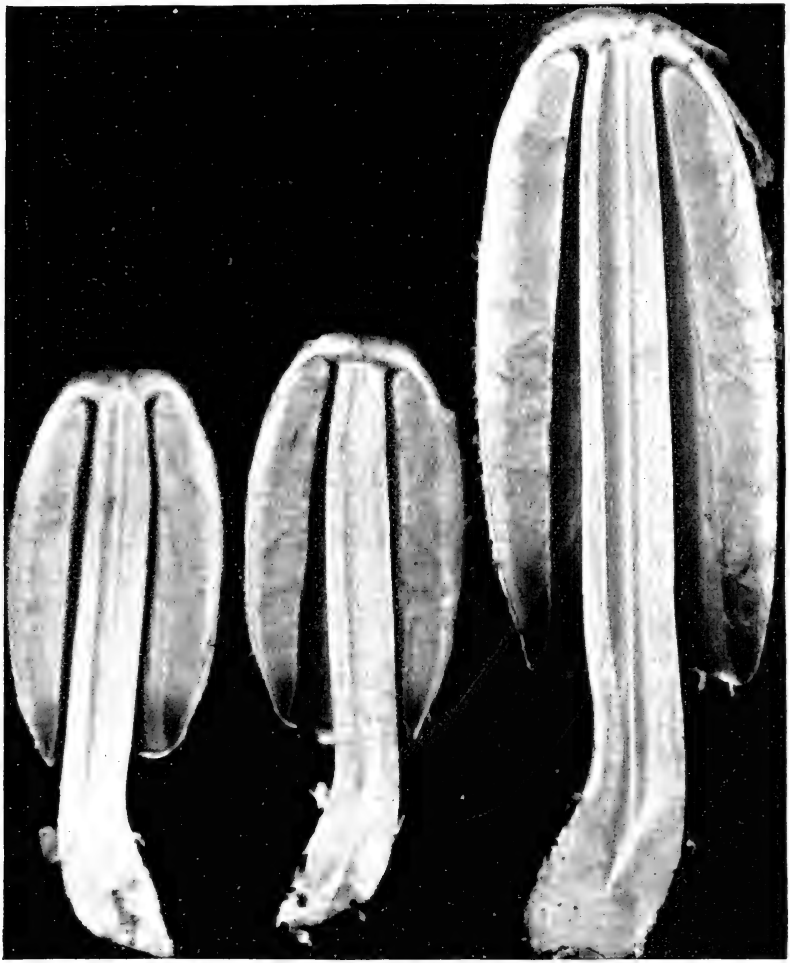
cease to grow, though they are firmly entangled with the inner layers. Now the threads underneath and all through the plant, in the gills and in the upper part of the stem grow and elongate rapidly. This pulls on the outer layer tearing it in the first place into small patches and causing them later to be more widely separated on the mature plant. Some of these scales remain quite large while others are torn up into quite small tufts.

87.—*Coprinus comatus, surface of pileus gathered in loups.* (*Natural size*).

As the plant ages, the next inner layers of the pileus grow less rapidly, so that the white layer beneath the brown is torn up into an intricate tangle of locks and tufts, or is frazzled into a delicate pile which exists here and there between well formed tufts. While all present the same general characters there is considerable individual variation as one can see by comparing a number of different plants. Figure 86 shows one of the interesting conditions. There is little of the brown color, and the outer portion of the pileus is torn into long locks, quite evenly distributed and curled up at the ends in an interesting fashion which merits well the term "shaggy." In others the threads are looped up quite regularly into triangular tresses which appear to be knotted at the ends where the tangle of brown threads holds them together as if some fairy had plaited the lock.

There is one curious feature about the expansion of the pileus

of the shaggy-mane which could not escape our attention. The pileus has become very long while comparatively little lateral



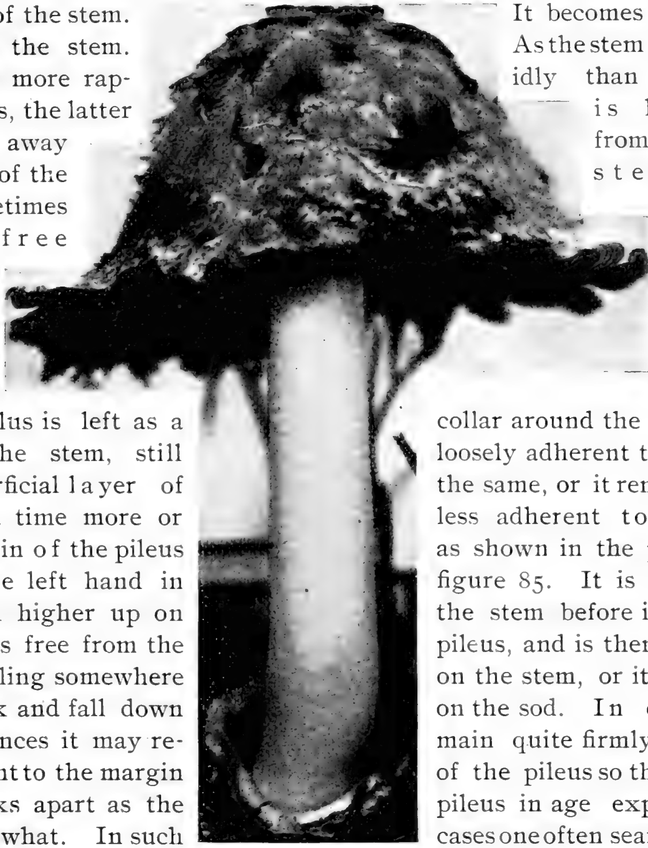
88.—*Coprinus comatus, sections of the three plants shown in figure 85.* (*Natural size*).

expansion has taken place. The pileus has remained cylindrical or barrel-shaped, while in the case of the mushrooms treated of in our first study the pileus expanded into the form of an umbrella.

The cylindrical or barrel-shaped pileus is characteristic of the shaggy-mane mushroom. As the pileus elongates the stem does also, but more rapidly. This tears apart the connection of the margin of the pileus with the base of the stem, as is plainly shown in figure 85. In breaking away, the connecting portion or veil, is freed both from the stem and from the margin of the pileus, and is left as a free, or loose ring, around the stem. In all of the plants of our former study, the common mushroom (*Agaricus campestris*), the smooth lepiota (*Lepiota naucina*), and the deadly amanita (*Amanita phalloides*), the ring remained attached to the stem, *i. e.*, it is not a free ring in those

89.—*Coprinus comatus, early stage of diliquescence. The ring is lying on the sod.* (*Natural size.*)

species. In the shaggy-mane the veil does not form a thin expanded curtain as in the three species just enumerated. It is really an annular outer layer of the button lying between the margin of the pileus and the base of the stem. It becomes free from the stem. As the stem elongates more rapidly than the pileus, the latter is lifted up away from the base of the stem. Sometimes the free annulus is left as a collar around the base of the stem, still loosely adherent to the superficial layer of the same, or it remains for a time more or less adherent to the margin of the pileus as shown in the plant at the left hand in figure 85. It is often lifted higher up on the stem before it becomes free from the pileus, and is then left dangling somewhere on the stem, or it may break and fall down on the sod. In other instances it may remain quite firmly adherent to the margin of the pileus so that it breaks apart as the pileus in age expands somewhat. In such cases one often searches for some time to discover it clinging as a sterile margin of the pileus, so closely does its outer texture resemble the outer texture of the pileus.



90.—*Coprinus comatus, later stage of diliquescence, pileus becoming more expanded.* (*Natural size*).

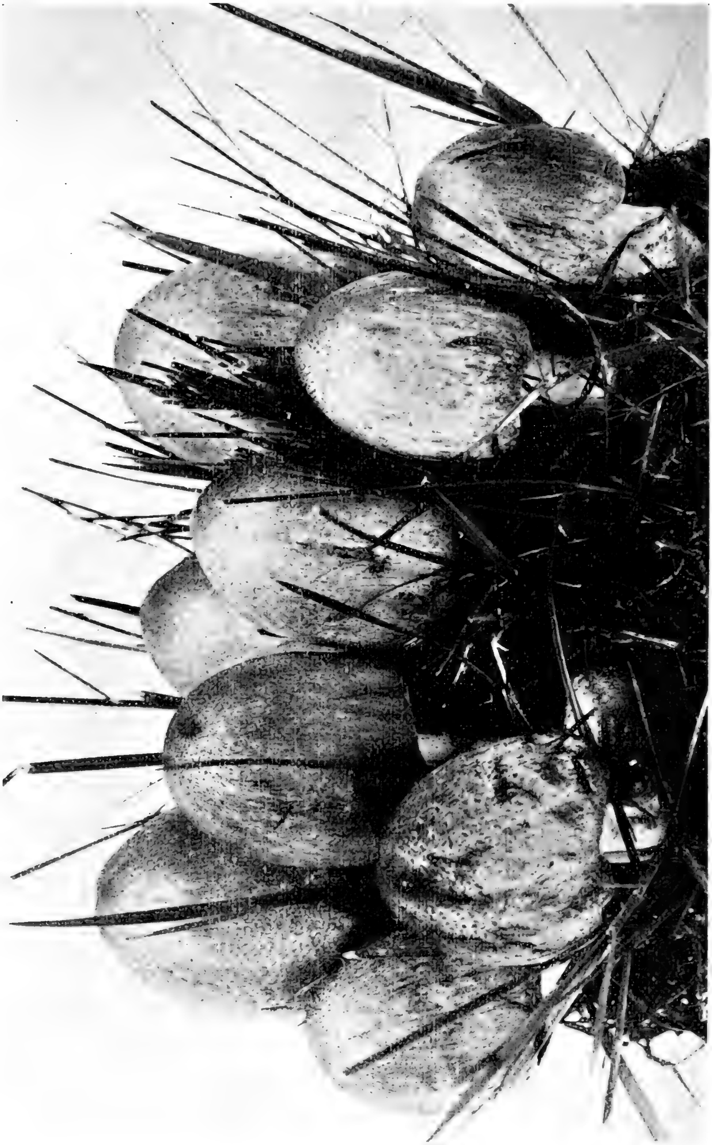
It is interesting to observe a section of the plants at this stage. These sections can be made by splitting the pileus and stem lengthwise through the middle line with a sharp knife as shown in figure 88. Here, in

the plant at the right hand, the "cord" of mycelium is plainly seen running through the hollow stem. This cord is well seen

91.—*Coprinus comatus, drops of inky fluid about to fall from wasted pileus.* (*Natural size*).

if one partly splits a stem and then gently pulls the halves apart. At the same time if the stem is held toward the light a very delicate mesh of threads, reminding one of the finest gauze, is seen extending from the cord to the wall of the tubular stem. The gills form a large portion of the plant for they are very broad and lie closely packed side by side. They are nowhere attached to the stem but at the upper end round off to the pileus leaving a well defined space between their ends and the stem. The pileus, while it is rather thick at the center, *i. e.*, where it joins the stem, becomes comparatively thin where it spreads out over the gills. At this age of the plant the gills are of a rich salmon color, *i. e.*, before the spores are ripe, and the taste when raw is a pleasant nutty flavor reminding one of the meat of fresh green hickory nuts. In a somewhat earlier stage the edges of all the gills are closely applied to the stem which they surround. So closely are they applied to the stem in most cases that threads of mycelium pass from the stem to the edge of the gills, so that they might be said to be "sewed" together. As the pileus expands slightly in ageing, these threads are torn asunder and the stem is covered with a very delicate down or with flocculent particles which easily disappear on handling or by the washing of the rains. The edges of the gills are also left in a frazzled condition as one can see by examining them with a good hand lens.

The spores now begin to ripen and as they become black the color of the gills changes. At the same time the gills and the pileus begin to dissolve into an inky fluid, first becoming dark and then melting into a black liquid. As this accumulates it forms into drops which dangle from the pileus until they fall away. This change takes place on the margin of the pileus first, and advances toward the center, and the contrast of color, as the blackening invades the rich salmon, is very striking. The pileus now begins to expand outward more, so that it becomes somewhat umbrella shaped. The extreme outer surface of the pileus does not diliquesce so freely, and the thin remnant curls upward and becomes enrolled on the upper side as the pileus with wasted gills becomes nearly flat.



92.—*The "ink-cap", Coprinus atramentarius, nearly smooth form.* (*Natural size*).

II.—THE INK-CAP (*Coprinus atramentarius*).

The ink-cap (*Coprinus atramentarius*) occurs under much the same conditions as the shaggy-mane, and is sometimes found accompanying it. It is usually more common and more abundant. It springs up in old or newly made lawns which have been richly

93.—*Coprinus atramentarius, scaly form.* (*Natural size.*)

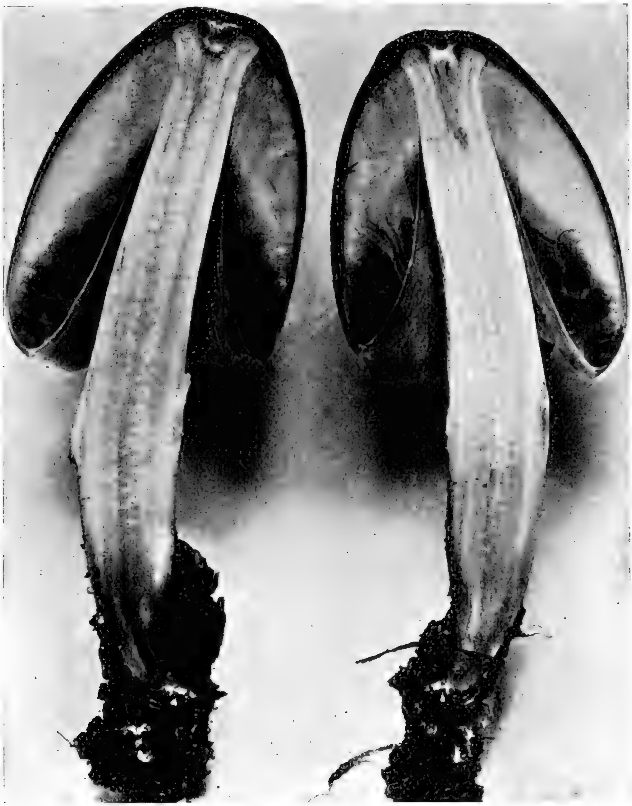
manured, or it occurs in other grassy places. Sometimes the plants are scattered, sometimes two or three in a cluster, but usually large clusters are formed where ten to twenty or more are crowded closely together (figure 92). The stems are shorter than those of the shaggy-mane and the pileus is of a different shape and color. The pileus is more egg-shaped or oval. It

varies in color from a silvery grey in a few forms, to a dark ashen grey, or smoky brown color in others. Sometimes the pileus is entirely smooth, as I have seen it in some of the silvery grey

94.—*Coprinus atramentarius; showing annulus as a border line between scaly and smooth part of stem.* (*Natural size.*)

forms, where the delicate fibres coursing down in lines on the outer surface cast a beautiful silvery sheen in the light. Other forms present numerous small scales on the top or center of the pileus which are formed by the cleavage of the outer surface here into large numbers of pointed tufts. In others, the delicate tufts cover more or less the entire surface, giving the plant a coarsely granular aspect. This is perhaps the more common appearance, at least so far as my observation goes. But not infrequently one finds forms which have the entire outer surface

of the pileus torn into quite a large number of coarse scales, and these are often more prominent over the upper portion. Fine lines or striations mark also the surface of all the forms, especially toward the margin where the scales are not so promi-



95.—*Coprinus atramentarius, section plant.* (*Natural size.*)

nent. The marginal half of the pileus is also frequently furrowed more or less irregularly, and this forms a crenate or uneven edge.

The annulus or ring on the stem of the ink-cap is very different from that of the shaggy-mane. It forms an irregularly zigzag elevated line of threads which extend around the stem near the base. It is well shown in figure 94 as a border line

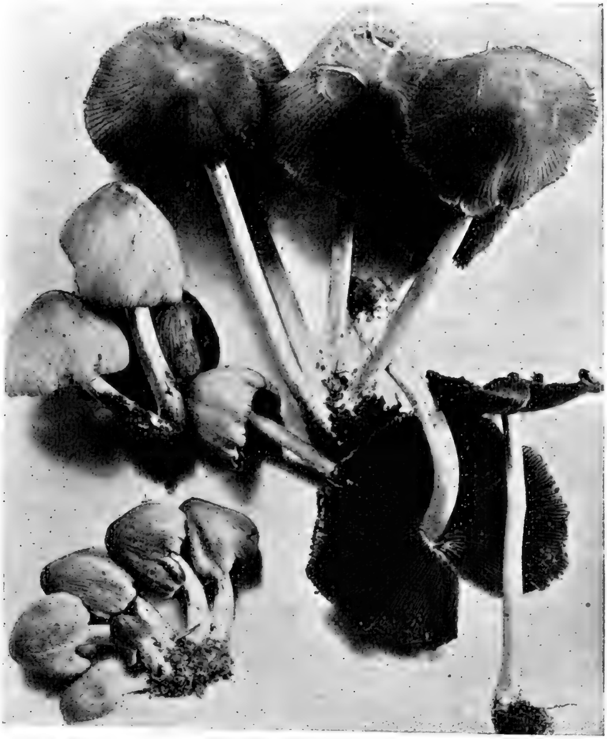
between the lower scaly end of the stem and the smooth white upper part. It is formed at the time of the separation of the margin of the pileus from the stem, the connecting fibres being pulled outward and left to mark the line of junction, while others below give the scaly appearance. It is easily effaced by rough handling or by the washing of the rains. A section of a plant is illustrated by a photograph in figure 95. On either side of the stem is shown the layer of fibres which form the annulus, and this layer is of a different texture from that of the stem. The stem is hollow as seen here also. In this figure one can see the change in color of the gills just at the time when they begin to diliquesce. This diliquescence proceeds much in the same way as in the shaggy-mane, and sometimes the thin remnant of the pileus expands and the margin is inrolled over the top.

III.—THE GLISTENING COPRINUS (*Coprinus micaceus*).

The third species described here is the glistening coprinus (*Coprinus micaceus*). It received this name because of the very delicate scales which often cover the surface of the pileus, and glisten in the light like particles of mica. This plant is very common during the spring and early summer though it does appear during the autumn. It occurs about the bases of stumps or trees or in grassy or denuded places, from dead roots, etc., buried in the soil. It occurs in dense tufts of ten to thirty or more individuals; sometimes as many as several hundred spring up from the roots of a dead tree or stump along the streets or in lawns, forming large masses. More rarely it occurs on logs in the woods, and sometimes, the plants are scattered in lawns. From the different habits of the plant it

96.—*The "glistening coprinus," Coprinus micaceus; young stage showing annulus, on the pileus the "mica" particles. (Natural size.)*

is sometimes difficult to determine, especially where the individuals are more or less scattered. However, the color of the plant, and the markings on the pileus, especially the presence of the small shining scales when not effaced, characterize the plant so that little difficulty is experienced in determining it when one has once carefully noted these peculiarities.



97.—*Coprinus micaceus, showing different aspects.*
(2-3 natural size.)

Figure 96 is from a group of three young individuals photographed just as the margin of the pileus is breaking away from the lower part of the stem, showing the delicate fibrous ring which is formed in the same way as in Coprinus atramentarius. The ring is much more delicate and is rarely seen except in very young specimens which are carefully collected and which

have not been washed by rains. The mature plants are 8 cm. to 10 cm. high (3–4 inches), and the pileus varies from 2 cm. to 4 cm. in diameter. The stem is quite slender and the pileus and gills quite thin as compared with the shaggy-mane and ink-cap. The gills are not nearly so crowded as they are in the two other species. The pileus is tan color, or light buff, or yellowish brown. Except near the center it is marked with quite prominent striations which radiate to the margin. These striations are minute furrows or depressed lines, and form one of the characters of the species, being much more prominent than on the pileus of the ink-cap.

In wet weather this coprinus melts down into an inky fluid also, but in quite dry weather it remains more or less firm, and sometimes it does not diliquesce at all, but dries with all parts well preserved though much shrunken of course as is the case with all the very fleshy fungi.

Many persons who are fond of mushrooms do not venture to collect and eat other species then the *Agaricus campestris*. Many will tramp considerable distances to collect the "pink gilled agaric," and pass by on the street, or perhaps in their dooryard, a clump of coprinus sufficient for a meal. During the spring and early summer the *Agaricus campestris* is not to be had in the open, while these three species of coprinus usually grow in abundance, though the shaggy-mane is usually more abundant in the autumn than in the spring.

During the autumn of 1898 the common "pink gilled mushroom" (*Agaricus campestris*) was very rare in the vicinity of Ithaca. This has led a few to search for other forms. Two of my friends during October brought into my office a peck basket filled with mushrooms, and wished to know if they were "good to eat." Nearly all of the plants were the "ink-cap" (*C. atramentarius*), there were four or five of the shaggy-mane (*C. comatus*), and a single "glistening coprinus" (*C. micaceus*). All of them good to eat and collected in a single dooryard. One of these gentlemen had never before ventured to partake of any other species than the *Agaricus campestris*.

During the early summer of 1897, while collecting a "mess"

of *Coprinus micaceus* from a large tuft growing around the base of a stump on one of the principal streets of Ithaca, a passer-by halted, probably for the charitable purpose of giving some information which he thought might save my life. "Them's toad-stools ain't they?" "Yes," I replied. "Well, I thought so," said he. Thereupon I ate one of the "toad-stools" raw, and received from him a look of mingled pity and despair as he passed on.

All of these three species have a somewhat nutty flavor, that of fresh hickory nuts when eaten raw, but they are more palatable when properly prepared for the table. The *Coprinus micaceus* need only be rinsed to remove from the caps any adhering particles of soil. The other two species may be peeled if it is desired to remove the outer and tougher layer of the pileus, or this may be done by gently scraping. The shaggy-mane peels well by starting at the margin of the pileus and with the fingers stripping off the outer layer. The ink-cap peels more readily by first splitting the pileus in halves and then starting the strip at the top of each half. It is sufficient, however, to gently scrape the surface of the pileus to remove the coarser outer fibers and whatever soil may adhere.

To those who are not acquainted with any of the species of coprinus and wish to extend the range of species collected for table use these three species are commended. The shaggy-mane is perhaps the most delicious of the three, but the other two are much more abundant usually. By a careful comparison of the species growing in lawns, and along streets with these descriptions, and especially with the illustrations, there should be no trouble in identifying them. While the camera here has not at present succeeded in reproducing all the colors, this series of photographs illustrates well the habit, texture and specific characters of the plants, and the color values in black and white are quite faithfully represented. It is doubtful if any hand coloring has yet succeeded in producing such perfect imitations as these photographic studies of the shaggy-mane and ink-cap. That they accurately portray the habit and specific characters of these plants I am convinced by the experience of my little boy of eight years. While selecting the illustrations for this study one evening, I

showed him the photographs, told him the names of each and the parts of the mushroom. The subject was not mentioned again until a week later when I brought in a few specimens of one of the species. "What is the name of this?" I said. "That's the shaggy-mane," he said. "What part is this?" "That's the cap." "And this?" That's the ring." "And this?" That's the stem." "Now, father," he said, "where's the ink-cap?" At another time he was able to select the ink-cap from among a miscellaneous collection.

While the *Coprinas micaceus* usually grows on decaying wood, or roots, etc., underneath the soil, the shaggy-mane and ink-cap grow in rich soil in grassy places, especially such as have been quite recently manured. This latter peculiarity of growing on manured ground, or on dung, so characteristic of a number of the species of the genus, suggested the name "*coprinus*," from the work "*kopros*," meaning dung.

A large number of the species of the genus, practically all the large fleshy ones (some of the smaller also) diliquesce into an inky fluid. In the delicate or membranous ones, usually quite small species, the pileus splits in radiating lines above each gill in such a way that the gill itself is split downward, thus giving to the pileus a fluted appearance.

In bulletin 138 the writer suggested the formation of mycological clubs as a medium for the exchange of information among interested persons in a given community. At that time there was already in existence among others, the Boston Mycological Club, New York Mycological Club and the Philadelphia Mycological Center. Since that time there have been organized the Washington Mycological Club, Chicago Mycological Club, and others.

CORNELL MYCOLOGICAL CLUB.

A mycological club has recently been organized at Cornell University, with a somewhat broader work in view. It is called the "Cornell Mycological Club" and is under the supervision of the members in the Botanical Department. Its purpose is to study the fungi, to propagate information concerning them among its members, and to encourage the growing popular interest in those

groups of economic importance, to which belong especially the edible, poisonous and parasitic fungi.

The rules governing the club are such that they admit to membership any person interested in its aims and work. No other qualifications except the payment of the small annual fee of twenty-five cents, are necessary, and any person sending name and enclosing the fee will be placed on the membership roll. This small fee is to be used in necessary expenses incurred relating to executive matters of the club, as determined by the Executive Council. With this small fee it will not be possible at present to publish a bulletin of information. It is hoped, however, that it will lead eventually to some medium of communication among members, by which a knowledge of the numerous local fungus floras may be obtained, and that this information as well as other matters of interest may be regularly communicated to members.

It is purposed to make the club a center to which persons interested in the study, and in becoming acquainted with the fungi, may appeal for aid in the determination of species they collect. To this end a few general directions are given here for those who desire to know how to put up specimens properly for mailing, so that they will not be broken or ruined in transit.

HOW TO MAIL FLESHY FUNGI.

Fresh "mushrooms," or "toad-stools" if of medium or large size, should be wrapped separately in tissue paper, or if the plants grow in tufts the paper can be worked in between the individual specimens unless the tuft is a compact one. A sufficient amount of paper should be used to give support to the expanded parts of the plant, and so arranged that delicate structures on the surface will not be rubbed away. The plants should then be packed quite firmly, but not crushed, into a tin box, or a light but strong wooden box. If they do not quite fill it more paper can be added, so that they will not jostle about, or they become badly broken. Pasteboard boxes are apt to become broken and ruin the specimens.

In collecting the mushrooms do not break off the stems, but pry the stems out of the earth carefully in order to preserve all

the characters on the lower end of the stem. Also use care in handling the stems so that the "collar," when present, and the delicate scales, be not rubbed off. The corky or woody fungi growing on trees, logs, stumps, etc., may be wrapped in the same way. In all specimens from logs or trees, the name of the wood should be given when that is accurately known. When the name of the tree is not known a portion of the wood and bark, or some leaves, nay accompany the specimen. The corky or woody fungi may be dried before mailing if desired. To dry the fleshy fungi requires considerable care, and usually artificial heat, for they must be dried quickly, not burned or roasted, though careful notes upon the characters of the plants while fresh, should also be made before they are dried, in most cases.

An extemporized oven for drying may be made of tin, with holes in the sides for ventilation. In this the plants can be placed in paper boxes while they are drying. The oven may then be placed above a stove, or a lamp may be placed underneath it. Shelves above a stove where warm air is constantly rising is a good place to dry the plants. The best place that I have ever used is the brick work around a large steam boiler, the plants, or boxes containing them, being placed directly on the brick work. Parasitic fungi on leaves of plants should be dried between absorbent paper under some pressure to keep the leaves from shriveling and curling.

Dried specimens of the mushrooms can be wrapped in tissue paper for shipment. It is better in most cases, however, if the plants are shipped away for determination, to send them in a fresh condition. At least some duplicates are desirable in a fresh condition, since fresh material is often necessary for determination of the species, especially with doubtful species, and in the case of many genera.

When fresh material is mailed, if the sender will use foresight in putting it up and mailing just in time for a mail train which makes good connections through, specimens will usually travel several hundred miles and arrive in a good condition.

Specimens sent by mail require, according to the present postal regulations, 1 ct. per 2 ounces in weight, and the package should be marked "plants." Wherever it is desired to

send by express, the sender should pay the express charges, except where good material prepared and named for the herbarium or museum is contributed, or where the sender is certain that the material is of value, as in the case of some rare specimens. In all cases where a list of the plants is desired in return, the sender should enclose a number with each specimen, so that the names can be given to correspond with the numbers. All desirable material will be preserved and kept in the herbarium here where it will be available for comparison and for study. For this reason the locality and date of collection and other notes of interest should accompany the specimens. After one has had some experience in the collection of these plants and in noting the important characters their specimens will be of more value. It is possible in this way for collectors to aid us in bringing together material from different sources which should assist in making these studies and illustrations of mushrooms more comprehensive and of wider usefulness.

From students of the fungi who have duplicate material in any of the groups, the Botanical Department will welcome contributions to the herbarium. Such gifts are certain to be of great usefulness at a center where students come for research. Not only is this branch of botanical study, as well as others emphasized, it is important to consider that mycological study here contributes to, and is supplemented by, other fields of research in related departments, as well as in the work of the Experiment Station, and in that of the newly organized College of Forestry.

Specimens may be sent to either of the following addresses :

PROFESSOR GEO. F. ATKINSON,
Botanical Department,
Cornell University, Ithaca, N. Y.

or,

CORNELL MYCOLOGICAL CLUB, Ithaca, N. Y.

Persons desiring to join the Club should send name with the annual fee enclosed, to either of the above addresses. The fee should *not be sent in postage stamps*, but preferably in a postal note when in so small a sum, unless the "quarter" is enclosed

in a mailing card for the purpose. The cost of sending will be reduced where several from the same locality choose to send names and fees in a single letter. The exact address should also be given for each person, with the street number where necessary.

Those wishing to take up the study of the fungi would find it profitable to attend some school where suitable opportunities are offered for beginners. A course in mycology* (devoted especially to the mushrooms) will be given during the summer of 1899 in the Botanical Department of Cornell University.

* Besides the course in mycology, courses in general morphology and physiology of plants, as well as a course in ecology are offered in the summer school especially for teachers. The catalog of the summer school can be obtained by addressing, The Registrar, Cornell University, Ithaca, N.Y. A full year's course in mycology is given during the regular annual session of the University as described in the annual Register.

NOTE.—The author was asissted in making some of the photographs illustrating this bulletin, by Mr. H. Hasselbring, and Mr. B. F. White.

Bulletin 169. May, 1899.

Cornell University Agricultural Experiment Station,

ITHACA, N. Y.

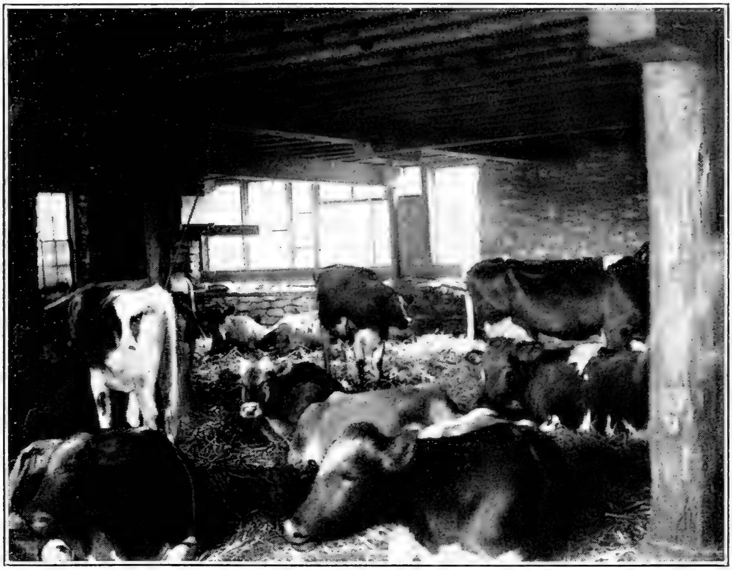
DAIRY DIVISION.

Studies in Milk Secretion

DRAWN FROM THE

RECORDS OF THE UNIVERSITY HERD

1891-1898.



By HENRY H. WING and LEROY ANDERSON.

PUBLISHED BY THE UNIVERSITY.

ITHACA, N. Y.

1899.

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STUDIES IN MILK SECRETION.

The University herd has consisted during the past several years of about twenty cows, the most of which have been grade Jerseys and grade Holsteins. In building up the herd the aim has been to form one that would furnish an object lesson to those farmers who desire to improve their herds but do not feel able to purchase thoroughbred stock entirely. Accordingly the herd has been developed from the ordinary stock of the neighborhood by the use of thoroughbred bulls and a rigid selection of the best heifers. This course of breeding was established by Professor Roberts in 1875 and has been continued ever since In 1874 the average yield of milk per cow was a little more than 3000 pounds. The descendants of these same cows, as will be seen in the following pages, have produced an average of over 7,500 pounds during the year 1897–'98. This increase of two and one-half times is the result of judicious selection of sire and dam, together with careful feeding, and is a result which every farmer can obtain by following a similar course.

The general management of the herd is on the plan of a winter dairy, *i. e.*, the cows are bred, so far as possible, to calve during the early fall months. They are milked about ten months and most of them are dry during July and August. In the summer they are at pasture which is supplemented with corn or other green forage crops whenever the pasture becomes dry or scanty. In the winter they are stabled at night and during the day run in a covered yard which is well bedded and where they have access to water, none being supplied in the stable. The frontispiece shows the cows in the covered yard mentioned.

Since the introduction of the Babcock test a careful record has been kept of the amount of butter-fat produced by the herd.

Each cow's milk is weighed daily and once a week a sample of an equal amount of nights and mornings milk is taken from each cow. The fat in these samples of mixed milk is determined by the Babcock test and this percentage multiplied by

the number of pounds of milk given during the week is taken to represent the number of pounds of fat produced during that week. Although this method does not give the actual amount of fat produced, still it gives a very close approximation thereto and is sufficiently accurate for practical purposes in estimating the producing power of any individual cow.

The records given in the following table (I) begin with September 1891 and continue until the fall of 1898 and are for all the cows which have been in the herd during that time. These records contain the cow's age, breed, date of calving, the number of the lactation period, the number ot weeks in the period, the total milk produced, the average per cent of fat and the total fat for the period. The breed of each cow is indicated by the initials following her name. J., designating Jersey, H., Holstein, T., Thoroughbred, G., Grade, and J.-H., Jersey-Holstein.

TABLE I.—PRODUCT OF MILK AND FAT.

Name of Cow.	Breed.	Age	Date of Calving.	Number of Lactation.	No. of Weeks in Lactation.	Total Pounds of Milk.	Average per cent Fat.	Total Pounds of Fat.
Aggie, 2nd.....	15/16 H.	2	Sept. 1892	1	27	3415.25	3.07	104.93
Beauty	G.J.	?	Jan. 1892	5?	35	6192.00	4.87	301.74
			Nov. 1892		39	6176.25	4.82	297.59
			Sept. 1893		41	6474.25	4.61	298.70
			Sept. 1894		41	6300.00	4.47	281.70
			Sept. 1895		24	4416.00	4.46	196.91
Belle	J.H.	2	Aug. 1897	1	52	7098.75	4.44	314.91
Belva.........	7/8 H.	5	Oct. 1891	4	42	9921.25	3.07	304.72
		6	Sept. 1892	5	46	9720.50	3.21	312.05
		7	Oct. 1893	6	40	9203.25	3.04	279.41
		8	Sept. 1894	7	34	8313.75	3.23	268.43
Belva, 2nd.....	15/16 H.	2	Sept. 1895	1	44	6272.00	3.29	206.45
		3	Sept. 1896	2	42	8300.25	3.16	262.17
		4	Sept. 1897	3	48	8746.50	3.22	281.79
Bertha.........	G.J.	3	Sept. 1891	2	42	4371.50	5.02	219.47
		4	Oct. 1892	3	45	5990.75	4.94	295.95
		5	Sept. 1893	4	42	5920.50	4.94	292.28
		6	Sept. 1894	5	44	6250.00	4.83	301.62
		7	Aug. 1895	6	59	8595.75	4.84	415.96
Bertha, 2nd....	G.J.	2	Jan. 1897	1	39	5630.50	4.66	262.02
		3	Jan. 1898	2	52	8150.00	4.63	376.02
Carrie	G.H.	2	Oct. 1891	1	84	9363.75	3.79	354.97
Cherry	G.J.	2	Sept. 1895	1	46	4085.50	5.44	222.46
		3	Sept. 1896	2	48	5442.25	5.37	292.40
		4	Oct. 1897	3	49	6299.50	5.33	335.87
Clara..........	G.J.	2	Oct. 1894	1	37	3547.00	5.28	187.31
		3	Sept. 1895	2	43	4405.50	5.08	223.67
		4	Sept. 1896	3	30	3893.00	4.99	194.08
Cora	G.J.	?	Jan. 1892	7?	38	5914.00	5.29	312.88
			Dec. 1892		34	5827.75	4.95	288.36
			Dec. 1893		17	3732.00	4.98	185.98
Daisy..........	G.J.	2	Sept. 1891	1	41	2203.00	5.91	130.13
		3	Sept. 1892	2	46	3433.00	5.60	192.32
		4	Sept. 1893	3	38	2669.5	5.63	150.21
		5	Sept. 1894	4	41	3698.25	5.56	205.50
		6	Sept. 1895	5	8	876.25	5.17	45.26

TABLE I.—*Continued.*

Name of Cow.	Breed.	Age	Date of Calving	Number of Lactation.	No. of Weeks in Lactation.	Total Pounds of Milk	Average per cent Fat.	Total Pounds of Fat.
Daisy 2nd.....	G.J.	2	Sep. 1896	1	45	3505.75	4.79	168.16
		3	Sep. 1897	2	24	2304.25	5.05	116.36
Dora..........	$\frac{15}{16}$H.	2	Aug. 1893	1	45	9325.75	3.15	293.96
		3	Aug. 1894	2	43	9450.50	3.14	297.20
		4	Sep. 1895	3	53	9681.00	2.93	283.93
		5	Nov. 1896	4	47	11905.00	3.00	356.73
		6	Dec. 1897	5	43	10926.75	3.03	331.38
Emma........	$\frac{15}{16}$H.	2	Feb. 1893	1	52	8421.50	3.17	267.33
		3	May 1894	2	59	10828.50	3.36	364.
		4	Aug. 1895	3	42	9396.75	2.93	275.02
		5	Sep. 1896	4	42	10258.00	3.01	308.79
		6	Aug. 1897	5	46	9500.00	2.98	283.51
Freddie.......	$\frac{3}{4}$ H.	6	Oct. 1891	5	41	10705.25	3.72	396.26
		7	Sept. 1892	6	42	9906.50	3.72	368.55
		8	Aug. 1893	7	45	11692.25	3.52	412.22
		9	Aug. 1894	8	38	10913.75	3.41	371.84
Garnet St. Lambert	T.J.	2	Oct. 1897	1	52	5894.50	4.92	290.05
Garnet Valentine.........	T.J.	2	Aug. 1893	1	46	4811.75	5.13	247.01
		3	Aug. 1894	2	43	5544.25	4.52	250.81
		4	Aug. 1895	3	43	5807.00	4.51	261.86
		5	Aug. 1896	4	44	4390.50	4.34	190.63
Gazelle.......	G.J.	4	Feb. 1892	2	35	4641.50	5.05	233.32
		5	Dec. 1892	3	38	5123.25	5.17	265.02
		6	Oct. 1893	4	39	5781.50	5.11	295.71
		7	Sep. 1894	5	39	4951.50	5.14	254.71
		8	Aug. 1895	6	18	2859.25	4.61	131.71
Gem Valentine.	T.J.	3	Mar. 1892	2	35	3258.25	5.78	188.56
		4	Jan. 1893	3	34	4536.50	5.64	255.86
		5	Nov. 1893	4	39	4732.75	5.61	265.43
		6	Oct. 1894	5	35	4063.50	5.58	226.83
		7	Sep. 1895	6	43	5144.00	5.42	278.78
		8	Sep. 1896	7	48	6103.75	5.50	335.46
		9	Oct. 1897	8	50	6458.75	5.24	338.82
Glista.........	T.H.	4	Sep. 1891	3	49	6935.50	3.49	241.80
		5	Oct. 1892	4	23	3048.50	3.56	108.49
Glista 2nd.....	T.H.	2	Sep. 1891	1	53	6082.00	3.12	189.58
		3	Nov. 1892	2	16	1451.75	2.89	42.00

TABLE I.—*Continued.*

Name of Cow.	Breed.	Age	Date of Calving.	Number of Lactation	No of Weeks in Lactation.	Total Pounds of Milk.	Average per cent Fat.	Total Pounds of Fat.
Glista 3rd.....	T.H.	2	Sep. 1893	1	45	8049.25	3.52	283.45
		3	Sep. 1894	2	40	5783.50	3.59	207.78
		4	Sep. 1894	3	34	5868.25	3.29	193.15
Glista 4th.....	T.H.	2	Oct. 1894	1	40	5850.75	3.78	220.06
		3	Sep. 1895	2	44	6819.75	3.21	219.26
		4	Sep. 1896	3	47	9854.50	3.30	325.28
		5	Sep. 1897	4	43	9076.75	3.23	292.75
Glista Netherland	T.H.	3	Oct. 1895	1	73	14780.00	3.21	474.64
		5	May 1897	2	61	12356.75	3.07	379.36
Jennie	G.J.	4	Mar. 1892	2	62	7118.00	5.12	364.37
		5	Aug. 1893	3	66	8440.75	5.40	456.06
Jennie 2nd.....	J.-H.	2	Nov. 1895	1	41	4746.75	4.28	203.01
		3	Nov. 1896	2	38	5759.50	4.26	245.44
		4	Oct. 1897	3	56	7161.50	4.32	309.51
Julia	⅞H.	2	Sep. 1893	1	45	7144.50	3.29	234.86
		3	Oct. 1894	2	40	7599.50	3.45	262.51
		4	Oct. 1895	3	40	9855.75	3.31	326.56
		5	Sep. 1896	4	47	7715.00	2.91	224.28
		6	Oct. 1897	5	40	8507.50	3.30	280.87
Mabel.........	$\frac{15}{16}$H.	2	Sep. 1892	1	46	7347.00	3.24	238.38
		3	July 1893	2	62	6938.50	3.45	239.30
		4	Jan. 1895	3	35	7984.25	3.85	307.86
Mabel 2nd	J.-H.	2	Oct. 1896	1	49	7301.75	4.05	296.14
		3	Nov. 1897	2	35	6162.00	3.89	239.87
May 2nd.......	⅞H.	2	Sep. 1894	1	41	5815.25	3.17	184.35
		3	Sep. 1895	2	47	6249.00	2.92	182.68
		4	Sep. 1896	3	41	7686.00	3.32	254.98
		5	Sep. 1897	4	58	10273.75	3.11	319.28
Mollie	$\frac{15}{16}$H.	2	Sep. 1891	1	41	7203.50	3.31	238.49
		3	Sep. 1892	2	42	8132.75	3.50	284.41
		4	Sep. 1893	3	51	10204.50	3.51	358.36
		5	Oct. 1894	4	40	9948.50	3.55	352.85
		6	Sep. 1895	5	52	11115.00	3.19	354.76

TABLE I.—*Continued.*

Name of Cow.	Breed.	Age	Date of Calving.	Number of Lactation	No. of Weeks in Lactation.	Total Pounds of Milk.	Average per cent Fat.	Total Pounds of Fat.
Mollie	15/16 H.	7	Oct. 1896	6	40	10991.00	3.30	363.21
		8	Sep. 1897	7	45	11023.50	3.14	345.75
Nora	7/8 H.	2	Sep. 1894	1	40	6093.50	3.41	207.58
		3	Aug. 1895	2	38	6994.25	3.40	237.46
Pearl	7/8 H.	3	Sep. 1891	2	44	9105.25	3.36	305.76
		4	Sep. 1892	3	41	8963.25	3.33	298.86
		5	Sep. 1893	4	43	10142.00	3.53	357.79
		6	Aug. 1894	5	75	13619.50	3.29	448.47
		8	May 1896	6	40	10764.75	3.26	351.32
Pet	7/8 H.	7	Mar. 1892	4	41	9647.50	3.34	322.55
		8	Apr. 1893	5	47	10208.25	3.38	344.80
		9	Apr. 1894	6	43	11482.50	3.58	410.64
		10	June 1895	7	15	4595.00	3.14	144.51
Pet 2nd	15/16 H.	2	May 1896	1	37	4360.50	3.31	154.50
		3	Mar. 1897	2	54	6416.00	3.32	213.25
Puss	7/8 H.	7	Dec. 1891	6	50	11835.25	2.96	349.94
		8	Feb. 1893	7	64	11951.25	2.85	340.22
Roxy	7/8 H.	2	Nov. 1892	1	42	6374.25	3.66	233.53
		3	Oct. 1893	2	45	3619.00	3.37	121.78
		5	Jan. 1895	3	17	3557.50	3.93	139.74
Ruby	3/4 H.	3	Sep. 1891	2	53	9174.50	3.49	320.23
		4	Nov. 1892	3	57	9968.25	3.44	342.84
		5	Feb. 1894	4	40	11086.00	3.49	386.50
		6	Jan. 1895	5	38	10781.50	3.42	369.01
		7	Dec. 1895	6	48	13574.00	3.17	430.15
		8	Dec. 1896	7	64	16089.50	3.24	521.32
Ruth	31/32 H.	2	Jan. 1897	1	39	6464.00	3.17	205.02
		3	Nov. 1897	2	38	5922.75	3.06	181.16
Sadie	15/16 H.	2	Mar. 1894	1	42	6441.75	3.51	226.12
		3	Mar. 1895	2	49	8305.50	3.49	289.46
		4	May 1896	3	50	8650.75	3.26	282.07
		5	June 1897	4	30	5006.75	3.45	172.97
Shadow	G.	?	Oct. 1891	?	49	8590.00	4.44	380.97
Sue	G.	?	Nov. 1891	?	53	10625.25	4.10	435.38
Valerie St. Lambert	T.J.	2	Sep. 1897	1	52	5679.50	5.04	286.16

A survey of the above table will call to mind some of the principles upon which are based the selection of animals for the herd. Several instances of short periods of lactation will be noted and these are almost invariably the last lactations of those cows which were no longer considered profitable and were therefore sent to the shambles. This is notably the case with some whose records appear for only a year or two, e. g. Daisy 2nd, Glista, and Glista 2nd. These were kept in the hope that they would show enough improvement over their first year's record to warrant their continuance in the herd. But as such improvement did not occur, they were sold to the butcher.

Attention is also called to the records of several heifers as compared to the performance of their dams. The cow Daisy was kept in the herd much longer than profitable in the anticipation that she might develop into something good. She did not do nearly so well as her dam, Cora, and was improved upon by her daughter, Daisy 2nd. The latter, however, made a poor record as a two-year-old, which, together with her poor promise the following year, made her keeping unprofitable. Three other heifers, Bertha 2d, Garnet St. Lambert, and Valerie St. Lambert, all sired by the same bull as Daisy 2nd (Cornell's Exile, 30778 A. J. C. C.) have records which bear a different relation to those of their dams than does that of Daisy 2nd. Bertha 2nd as a two-year-old, exceeded her dam Bertha, in both milk and butter production when three years old. And her three-year-old record is better than any record of her dam until the latter reached the age of seven years. Garnet St. Lambert as a two-year-old produced more milk and fat than her dam Garnet Valentine in any year of her life. The latter died of milk fever in September 1897. The dam of Valerie St. Lambert was Gem Valentine, and she gives promise, judging from her two-year-old performance, of being a more profitable cow than her dam.

Of the four heifers mentioned, all did better than their dams, but even this fact, in the case of Daisy 2nd, did not make her a profitable cow, because both dam and daughter were light producers. The dams of the other three were fairly good cows and as the daughters were improvements upon them, the latter were of still greater value. This illustration goes to show the advisa-

bility of selecting heifers from the best cows rather than depending too much upon the good qualities of the sire.

Three of the cows are the product of a Jersey-Holstein cross. Jennie, a grade Jersey, was the dam of Jennie 2nd by a thoroughbred Holstein-Friesian bull. A comparison of their four-year-old records shows the daughter to have produced more milk but less fat than the dam. In that year the former's average per cent of

98.—*Ruby at two years of age.*

fat was .8 of one per cent less than that of the latter. Mabel 2nd is the result of breeding Mabel, a high-grade Holstein-Friesian to a thoroughbred Jersey bull, Cornell's Exile. As a two-year-old the daughter produced slightly less milk and more fat than the dam, while as a three-year-old she produced more milk and fat for the same number of weeks than her dam. Her per cent of fat was about three-fourths of one per cent higher than Mabel's for the first two years. Belle is also by Cornell's Exile and is out of Ruby, a three-fourths Holstein-Fresian cow. Ruby's record as a two-year-old does not appear, but in compari-

son to her three-year-old performance, Belle's production when two years old is over 2,000 pounds less in milk and about five pounds less in total butter fat. This great difference is occasioned by Belle averaging about one per cent higher in fat than her dam. Ruby produced 8,448 pounds of milk as a two-year-old and had she averaged the same per cent of fat as when three years old, Belle's record for butter fat at the same age would have exceeded hers by twenty pounds.

99.—*Kate daughter of Ruby at two years of age.*

The longest single period of lactation was that of Glista Netherland for 73 weeks. This was her first lactation and during this time she produced 14780 pounds of milk containing 474.64 pounds of butter-fat. A comparison of her record with that of Glista 4th will be of interest, since they are practically of the same age and are very closely related, both being by the same sire and Glista 4th's dam is Glista Netherland's grand dam. Glista 4th has had four calves; been in milk a total of 174 weeks and produced 31601.75 pounds of milk and 1057.35 pounds

of fat. Glista Netherland during practically the same time has had two calves; been in milk 134 weeks; and produced 27136.75 pounds of milk and 854 pounds of fat.

The largest yield of milk for one lactation period was that of Ruby as an eight-year old, or 16089.50 pounds in 64 weeks. Her production of fat for this period was 531.32 pounds equivalent to 625 pounds of butter containing 85 per cent fat. As a

100.—*Ruby at ten years of age.*

two-year old she gave promise of being a good cow by producing in one year 8448 pounds of milk. Her picture is here reproduced as she appeared when two years old and also one taken in the fall of 1898 when ten years old. A picture of her daughter, Kate, now two years old, is also given to show the close resemblance between calf and dam at the same age. Kate dropped her first calf Sept. 16, 1898 and up to April 1st 1899 had produced 3684 pounds of milk. This is much less than her dam gave in the same length of time and it will be interesting to see if she ever resembles her as much in production as in appearance.

AVERAGE PRODUCTION.

The average production of all the cows for each year is given in Table II, together with the highest and lowest records for that year. These records were selected according to the relative production of butter-fat and without regard to the yield of milk. Since most of the cows are fresh in the Fall, the "dairy year" is considered to run from September first to August thirty-first and the averages are for the production of the cows during that period.

TABLE II.—AVERAGE PRODUCT OF MILK AND FAT.

Year.		Number of cows.	Age.	Pounds of milk.	Per cent. fat.	Pounds of fat.
1891–'92..	Average........	19	4.0	7163.42	3.94	282.07
	Highest (Sue)...		5?	10625.25	4.10	435.38
	Lowest (Daisy)..		2	2203.00	5.91	130.13
1892–'93..	Average........	17	4.6	6875.00	3.93	270.28
	Highest(Freddie)		7	9906.00	3.72	368.55
	Lowest (Carrie).		2	4122.50	4.08	168.30
1893–'94..	Average........	19	4.5	7563.32	3.86	291.92
	Highest (Pet)..		8	11782.25	3.55	418.03
	Lowest (Roxy)..		3	3619.00	3.37	121.78
1894–'95..	Average.........	22	4.8	7162.95	3.77	270.12
	Highest (Ruby).		6	11816.00	3.40	402.27
	Lowest (May 2d).		2	5815.25	3.17	184.35
1895–'96..	Average........	19	4.2	7456.25	3.57	265.88
	Highest (Ruby).		7	13446.75	3.19	428.75
	Lowest (May 2d)		3	6249.00	2.92	182.68
1896–'97..	Average........	20	4.2	7495.43	3.62	271.66
	Highest (Ruby).		8	13416.00	3.23	432.83
	Lowest(Daisy2d)		2	3505.75	4.79	168.16
1897–'98..	Average........	19	4.7	7575.33	3.68	278.51
	Highest (Mollie).		8	11023.50	3.14	345.75
	Lowest (Pet 2d).		3	4682.75	3.29	154.11
	Average of all..	135	4.4	7331.60	3.76	275.69

From this table it is seen that the largest production of fat for any one year was 435.38 pounds. This was from 10,625.25 pounds of milk containing an average of 4.1 per cent fat. The

largest yield of milk for one year was 13,446.75 pounds which contained an average of 3.19 per cent fat and a total of 428.75 pounds of fat. The smallest production of fat was in the year 1893–94 and was 121.78 pounds. This was from 3,619 pounds of milk containing an average of 3.37 per cent fat. The smallest yield of milk was 2,203 pounds in the year 1891–92. This contained an average of 5.91 per cent fat and a total of 130.13 pounds of fat. The annual average yield of milk varied from 6,875 pounds in 1892–93 to 7,575 pounds in 1897–98. The average production of fat varied from 265.88 pounds in 1895–96 to 291.92 pounds in 1893–94. The lowest average per cent of fat (3.57) was also in 1895–96, while the highest average (3.94) was in 1891–92. The average of all the cows for the seven years was 7,331.6 pounds of milk, 275.69 pounds of fat and 3.76 per cent fat. The average age for each year ranges from 4 years in 1891–92 to 4.8 in 1894–95. The average age for seven years is 4.4 years. It should be noticed that the lowest record for each year was by either a two or three year old, while the highest record was in each case by a full aged cow.

PRODUCTION AS INFLUENCED BY AGE.

With a view to determine the average gain in production as a cow increases in age, we have taken from the records that go to make up Table I, such records as there are beginning with two-year olds and continuing for two or more years. In order to make this comparison as just as possible, the first forty weeks in each period of lactation are taken to represent the cows production for that period. In only a comparatively few cases do the periods taken in this comparison fall short of forty weeks and these instances are noted in the table. While the shorter periods may work to the slight disadvantage of the cow concerned, still they do not materially affect the average of the whole, which is the most important part of the comparison. The milk records of Bertha, Gem Valentine, Pearl and Ruby as two-year olds were made during the year 1890–91 when the milk was not tested for fat and thus the amount of fat produced cannot be given. This comparison is shown in the following table (III) and along with the forty week records, is given the per cent of gain in milk and fat from one year to another.

TABLE III.—THE YIELD OF MILK AND FAT COMPARED ACCORDING TO AGE OF ANIMAL.

Name of cow.	Age.	Pounds of milk.	Per cent of increase or decrease.	Pounds of fat.	Per cent of increase or decrease.
Belva 2d	2	6034.75		195.49	
	3	8163.75	+35.2	256.74	+31.3
	4	8000.50	— 2.0	256.00	— 0.3
Bertha	2	4554.00			
	3	4225.25	— 7.2	212.66	
	4	5601.25	+32.6	274.41	+29.0
	5	5785.50	+ 3.3	286.15	+ 4.3
	6	6003.00	+ 3.8	289.19	+ 1.1
	7	6243.00	+ 4.0	296.22	+ 2.4
Bertha 2d	2	5630.50		262.20	
	3	6490.75	+15.3	293.80	+11.2
Cherry	2	3810.75		205.33	
	3	4741.00	+24.4	252.15	+22.8
	4	5638.25	+18.9	300.35	+15.1
Clara	2 c	3547.00		187.31	
	3	4221.25	+19.0	212.53	+13.5
Daisy	2	2149.00		127.13	
	3	3216.00	+49.2	178.81	+40.7
	4 d	2669.50	—17.0	150.21	—16.0
	5	3657.00	+37.0	203.11	+35.2
Dora	2	8758.50		271.52	
	3	9192.00	+ 4.9	287.95	+ 6.1
	4	8514.75	— 7.3	248.57	—13.7
	5	11241.00	+32.0	335.84	+35.1
	6	10545.75	— 6.2	318.42	— 5.2
Emma	2	7355.75		233.33	
	3	8584.75	+16.7	282.15	+20.9
	4	9303.00	+ 8.4	271.59	— 3.7
	5	10061.75	+ 8.2	301.98	+11.2
	6	8767.00	—12.8	259.15	—12.7
Garnet Valentine	2	4455.75		228.06	
	3	5395.00	+21.1	243.97	+ 7.0
	4	5626.00	+ 4.3	253.96	+ 4.1
	5	4306.50	—23.5	186.84	—26.4
Gem Valentine	2	5177.25			
	3 b	3258.25	—37.1	188.56	

b. 35 weeks. c. 37 weeks. d. 38 weeks.

TABLE III.—*Continued.*

Name of cow.	Age.	Pounds of milk.	Per cent of increase or decrease.	Pounds of fat.	Per cent of increase or decrease.
Gem Valentine......	4 a	4536.50	+39.2	255.86	+35.7
	5 e	4732.75	+ 4.3	265.43	+ 3.7
	6 b	4063.50	—14.1	226.83	—14.5
	7	4981.00	+22.6	269.31	+18.7
	8	5585.25	+12.1	306.27	+13.7
	9	5710.50	+ 2.2	299.17	— 2.3
Glista 3rd............	2	7666.00		265.61	
	3	5783.50	—24.6	207.78	—21.8
	4 a	5868.25	+ 1.5	193.15	— 7.0
Glista 4th............	2	5850.75		220.06	
	3	6539.75	+11.8	208.36	— 5.3
	4	8926.75	+36.5	291.38	+39.8
	5	8869.75	— 0.6	284.78	— 2.3
Jennie 2d............	2	4708.25		201.20	
	3 d	5759.50	+22.3	245.44	+22.0
	4	6075.25	+ 5.5	260.39	+ 6.1
Julia	2	6910.25		225.51	
	3	7599.50	+10.0	262 51	+16.4
	4	9855.75	+29.7	326.56	+24.4
	5	7237.50	—26.6	207.18	—36.6
	6	8507.50	+17.5	280 87	+35.6
Mabel	2	6781.75		218.54	
	3	5082.50	—25.1	173.40	—20.7
	4 b	7984.25	+57.1	307.86	+77.5
Mabel 2d	2	6397.00		257.08	
	3 b	6162.00	— 3.7	239.87	— 6.7
May 2d.............	2	5630.50		180.88	
	3	5785.50	+ 2.8	168.00	— 7.1
	4	7640.25	+32.1	253.17	+50.7
	5	7838.00	+ 2.6	246.61	— 2.6
Mollie	2	7068.00		233.14	
	3	7828.00	+10.8	271.75	+12.3
	4	9145.25	+16.8	317.48	+16.8
	5	9948.50	+ 8.8	352.85	+11.1
	6	9732.00	— 2.2	308.78	—12.5
	7	10991.00	+12.9	363.21	+17.6
	8	10302.25	— 6.3	321.34	—11.5
Nora	2	6093.50		207.58	
	3 d	6994.25	+14.8	237.46	+14.9

a. 34 weeks. b. 35 weeks. c. 37 weeks. d. 38 weeks. e. 39 weeks.

TABLE III.—*Continued.*

Name of cow.	Age.	Pounds of milk.	Per cent of increase or decrease.	Pounds of fat.	Per cent of increase or decrease.
Pearl	2	6816.25			
	3	8666.00	+27.1	289.32	
	4	8963.25	+ 3.4	298.86	+ 3.3
	5	9952.75	+11.0	350.29	+17.2
	6	9041.50	— 9.2	300.95	—14.1
	7	10764.75	+19.1	351.32	+16.7
Pet 2d	2 c	4360.50		154.50	
	3	5332.75	+22.3	173.56	+12.3
Roxy	2	6317.25		230.96	
	3	3475.50	—45.0	116.12	—49.7
Ruby	2	7235.00			
	3	7442.00	+ 2.9	252	
	4	8249.50	+10.9	284.18	+12.8
	5	11086.00	+34.4	386.50	+36.0
	6 d	10781.50	— 2.7	369.01	— 4.5
	7	12740.00	+18.2	401.41	+ 8.8
	8	12576.50	— 1.3	404.20	— .07
Ruth	2 e	6464.00		205.02	
	3	5922.75	— 8.3	181.16	—11.6
Sadie	2	6352.50		222.37	
	3	7480.75	+17.8	257.97	+16.0
	4	7700.75	+ 2.9	249.95	— 3.1

c. 37 weeks. d. 38 weeks. e. 39 weeks.

AVERAGE OF RECORDS SHOWN IN TABLE III.

	No. of cow	Pounds of milk.	Per cent of increase.	Pounds of fat.	Per cent of increase.	Average per cent of fat.
Two-year olds	25	5844.99		*215.85		3.71
Three " "	25	6133.69	5.0	227.76	5.5	3.71
Four " "	18	7238.83	18.0	266.33	16.9	3.68
Full-aged cows	29	8346.66	15.3	302.52	13.6	3.62
Five-year olds	12	7893.08		283.96		3.60
Six " "	8	8430.22		294.15		3.49
Seven " "	5	9143.95		336.29		3.68
Eight and nine-year olds	4	8543.63		332.75		3.89
Average of all	97	6925.97		255.85		3.67

* Twenty-one two-year olds.

In this comparison there are 97 records of milk and 93 of fat production, 25 of the milk and 21 of the fat records being of two-year olds. Of the remainder the same number of animals are represented in both milk and fat, and of these, 25 are three year-olds, 18 four-year olds and 29 full aged cows. The average yield of all the cows was 6926 pounds of milk and 255.85 pounds of fat with an average of 3.67 per cent fat. The average increase in milk was five per cent from two to three year olds, 18 per cent from three to four year olds, and 15.3 per cent from four-year olds to full aged cows. The average increase in production of fat was 5.5 per cent from two and three year olds, 17 per cent from three to four year olds, and 13.6 per cent from four-year olds to full aged cows.

It will be noticed that the greatest increase in both milk and fat is from the ages of three to four while the smallest increase is from the ages of two to three. This is quite contrary to what was found in the case of seven day tests of thorough bred Holstein-Friesian cows, the records of which were published in Bulletin No. 152 of this Station. The gains of the older cows over the younger were so different in the two cases that the per cent increase in each is given in tabular form below for ready comparison.

PER CENT INCREASE.

	Milk.		Fat.	
	University Herd 40 Weeks.	Seven day test. Bul. 152.	University Herd 40 Weeks.	Seven day test. Bul. 152.
From two to three year olds	4.9	28.5	5.5	32.7
" three to four "	18.0	12.6	16.9	18.2
" four to five "	15.3	7.5	13.6	7.7

Were it a question as to which gives the more accurate estimate of the producing power of older cows over younger, the choice would undoubtedly fall to the records here given of the University herd. The latter is kept under conditions such as

are found in all well conducted dairies and the records cover nearly, if not quite, the average yearly milking period of the ordinary cow. On the other hand the cows which are entered for the seven day tests are the pick of the herd; they are fed to the highest limit for a short period and thus forced to their utmost production for that time. Moreover the records are for too short a time to furnish an accurate estimate of the relative production of cows of different ages. Forty week records must, in the nature of the case, give us a surer basis of comparison than those which run for seven days only.

VARIATION IN YIELD OF MILK AND ITS FAT CONTENT AS LACTATION ADVANCES.

A point often discussed concerns the average rate of decrease in yield of milk as the period of lactation advances and also the average increase, if such there be, in the per cent of fat during the same time. As an indication of what this decrease in milk and increase in per cent of fat may be, a careful study was made of the individual records of all the cows in the herd. This study was conducted in the following manner: Beginning with the third week after calving the weekly records of each cow were divided into periods of four weeks each. The average daily yield of milk and the average per cent of fat were then determined for each of these periods. Considering the averages for the first period of four weeks in each lactation as 100, the average for each succeeding period was calculated to the same basis. The first two weeks after calving were thrown out of the calculation because so many abnormal conditions affect the flow of milk at that time. The records were worked out in this manner for each individual cow in each year, and from these were obtained the averages for seven years which appear below in Table IV. In this table also are given the yearly records of six individual cows representing various degrees of fluctuation in yield of milk and in per cent of fat. An explanation of the figures may be of value. In 1893–94, Dora (II.) had a daily average of 31 pounds of milk during the first four weeks of her lactation. If we represent this average of 31 as 100, then on the same basis her daily average for the next four weeks of 28.25

pounds, a decrease of nine per cent, would be represented by 91. In like manner her daily average of 31 pounds during the third period would be represented by 100. And so on through the whole period of lactation we reckon the average daily yield of each four weeks according to the ratio it bears to the yield in the first four weeks when considered as 100. The relative increase or decrease in per cent of fat was determined in the same manner, and is given in the table along with the variation in milk yield.

Following this table are three plates showing lines platted according to the figures given in the table. These lines show very plainly the variation in milk and per cent of fat from month to month. The record which each set of lines is intended to display is indicated by the Roman numeral which corresponds to the same number in table IV. Passing from left to right in these plates, each perpendicular line represents four weeks advance in the lactation period, and each space between the horizontal lines represents two pounds of milk or .2 of 1 per cent of fat. Keeping these points in mind, the reader, beginning at 100, will easily trace each record for milk and per cent. of fat as given in table IV.

TABLE IV.—RATIO OF VARIATION IN YIELD OF MILK AND PER CENT OF FAT, COUNTING THE DAILY AVERAGE FOR THE FIRST FOUR WEEKS AS 100.

Number of periods of four weeks each after calving.	I. Average for 135 cows.		II. Dora, 1893-94.		III. Mollie, 1895-96		IV. Belva 2d, 1896-97.		V. Daisy, 1892-93.		VI. Pet, 1893-94.		VII. Cherry, 1896-97.	
	Milk.	Per ct. fat.	Milk.	Per ct. fat.	Milk.	Per ct. fat.	Milk.	Per ct. fat.	Milk.	Per ct. fat.	Milk.	Per ct. fat.	Milk.	Per ct. fat.
1st actual....			31.00	3.16	35.25	3.55	29.00	3.20	15.00	5.10	40.75	2.72	21.75	4.80
1st relative..	100	100	100	100	100	100	100	100	100	100	100	100	100	100
2d...........	96	96	91	95	97	83	105	93	80	100	110	113	88	109
3d	93	96	100	97	100	87	104	86	84	102	102	112	80	110
4th..........	89	97	109	90	103	89	108	94	79	110	99	131	70	116
5th..........	85	98	106	94	100	87	107	95	80	100	100	112	66	121
6th..........	81	98	97	94	100	90	109	100	79	110	68	131	70	116
7th	76	102	103	100	98	89	107	95	68	125	63	132	70	112
8th..........	71	103	105	99	97	90	108	108	63	119	63	144	81	114
9th..........	67	104	98	111	98	94	91	105	67	118	67	140	76	115
10th..........	62	104	100	108	84	91	46	118	57	115	58	150	68	111
11th..........	55	106	57	129	53	96			39	122	36	153	53	121

The average of all (I) includes 135 yearly records and such a large number must give a fair representation of the average decrease in yield of milk and increase in per cent of fat as the period of lactation advances. This average shows a gradual and fairly regular decrease in milk flow from the time of calving until the cow is dry. The decrease from one period of four weeks to the next varies from 3.1 to 11.3 per cent, while the average decrease is 5.3 per cent. This calculation also shows a decrease in the per cent of fat from the first month to the second and then

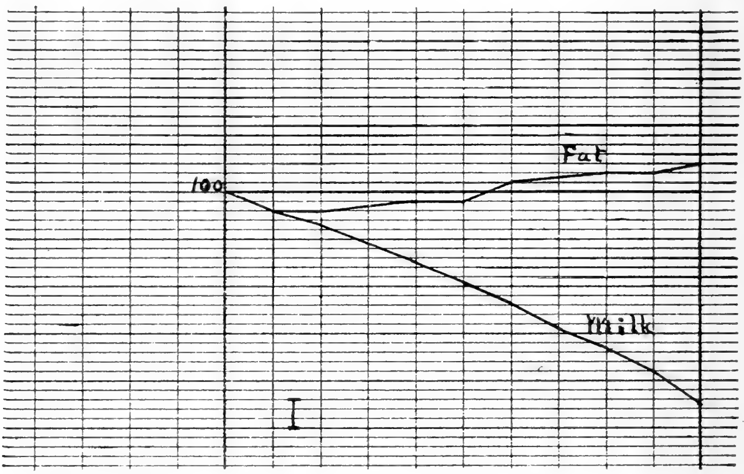

Diagram showing average variation in yield of milk and fat as lactation progresses.

a gradual rise to the end of the lactation period. The variation from one period of four weeks to the next is from minus 4 per cent to plus 4.1 per cent, while the average increase is slightly more than one-half of one per cent. The average per cent of fat during the eleventh month is only six per cent greater than during the first month. At no time during the milking period does the increase in per cent of fat compensate for the loss in yield of milk, in the production of total butter fat. This may be the case for a time with some individual cows but as a rule it does not occur so far as our records show. In other words a cow may generally be depended upon to give a larger yield of butter fat

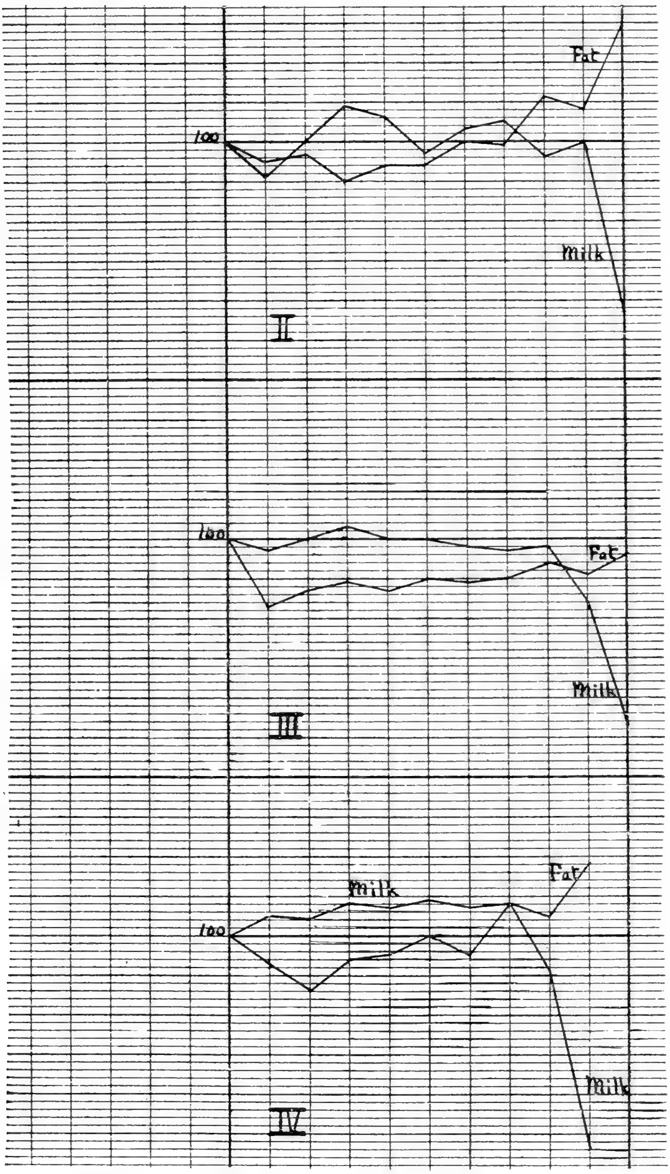

Diagram showing individual variations in milk and fat as lactation progresses.

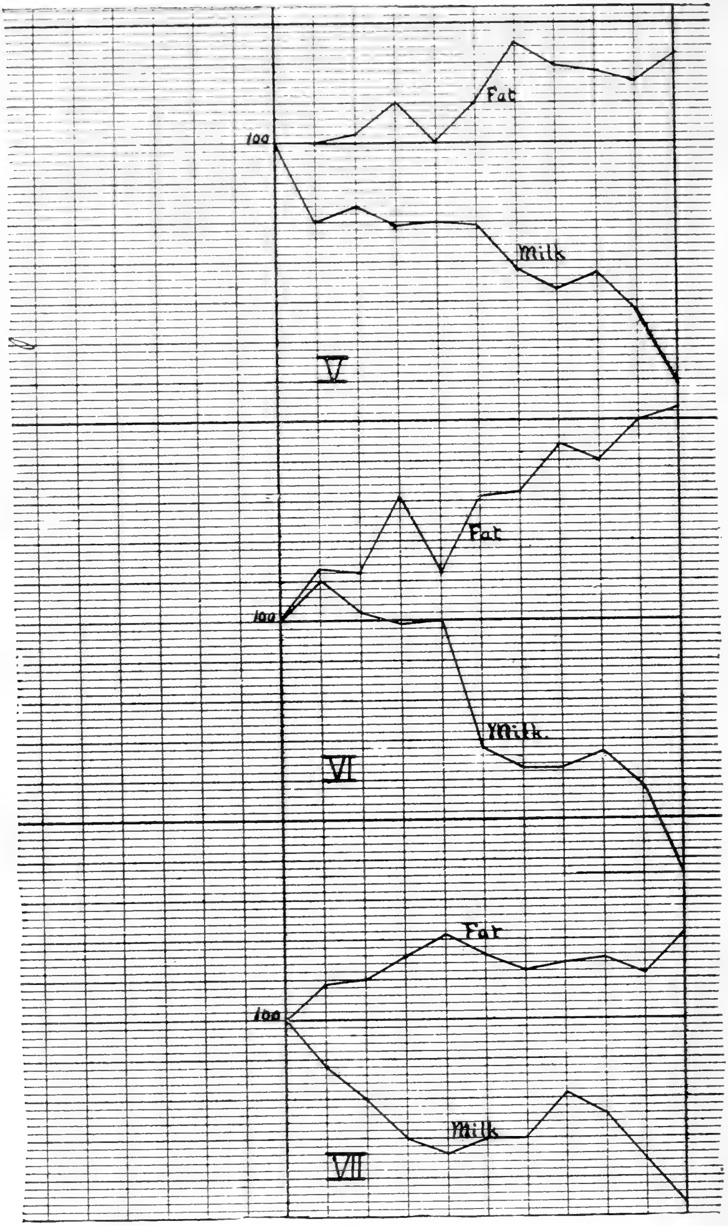

Diagram showing individual variations in milk and fat as lactation progresses.

during the first weeks of a milking period than at any subsequent time during the same lactation.

The record given of Dora (II), August, 1893 to July, 1894, is of her production as a two-year old. During this year she displayed a remarkable "holding out" power. In the second month she fell off in the daily average nine per cent, but for the next ten months she fell below her first average only twice and then no more than three per cent. At the end of the tenth period she declined so rapidly in milk that she was completely dry before the close of the eleventh. In per cent of fat she showed a variation which is found by these studies to be quite common, namely, a decrease for the second or third four weeks, and then a gradual rise to the close of the milking period. She dropped her second calf August 30, 1894, three days more than a year from her first calving. She "held out" in milk as a two-year old better than during any succeeding year.

Mollie (III) September, 1895 to September, 1896, displayed almost as continuous a milk flow as Dora in 1893–94. Beginning the first four weeks with a daily average of 35.25 pounds, she did not decrease more than three per cent until the tenth period, when she fell off 16 per cent and then declined rapidly until dry in the thirteenth period. In per cent of fat she was higher during the first month than at any other period except at the last end of lactation. This was her fifth lactation and her sixth calf was dropped 13½ months after the fifth.

Belva 2nd (IV.) September 1896 to July 1897, likewise showed much power in "holding out" in her milk flow. At the end of the eighth four weeks, her daily average had not fallen below that of the first period, but then she declined rapidly and went dry at the end of the tenth four weeks. In per cent of fat she shows much the same characteristics as were noted in Dora (II). This was her record as a three-year-old and her third calf was born a little less than a year after the second.

Daisy (V.) September 1892 to July 1893, showed a decrease in milk flow which is rather more than the average and at the same time an increase in per cent of fat which is much greater than the average. During the seventh month the per cent of fat rose 25 per cent above the average for the first four weeks and this

without any apparent cause so far as the records show. After this there was a decrease and again a rise to 22 per cent above the first month at the end of lactation. This was her second year in milk and her third calf was dropped one year after the second.

Pet (VI.) April 1893 to March 1894, showed the greatest increase in per cent of fat of any of the cows in the herd, it having increased gradually until at the last of the milking period it was over 50 per cent greater than at the beginning. At the same time the decrease in flow of milk was very great after the close of the fifth month. During the following month it fell off 32 per cent. This great decrease was occasioned by her being taken to the New York State Fair. On September 13, 1893 her milk yield at the home barn was 35.75 pounds. The next day she was at the Fair grounds and gave only 26.5 pounds. She did not again recover her former yield. When the milk flow thus fell 32 per cent the per cent of fat rose 31 per cent, but it should be noted that the per cent of fat reached as equally high a point during the fourth month. The average per cent of fat for the first four weeks of this lactation was lower then for a similar period of any other year. This low average may have been abnormal with her and thus show an unusual increase as the period of lactation advanced. It was her fourth lactation and her fifth calf was dropped about one year after the fourth.

Cherry (VII.) September 1896 to August 1897, represents another instance where the per cent of fat was lower during the first few weeks than at any subsequent time during the same lactation period. And like Pet mentioned above, the per cent of fat at the beginning of this milking period was lower than for a similar time during any of her other lactations. This may account for the more than average increase in the per cent of fat as the lactation advanced. She dropped her second calf Sept. 18, 1896, and her third calf Oct. 28, 1897.

EFFECT OF THE CHANGE FROM BARN TO PASTURE.

When cows are turned from dry stall feed into the fresh pasture of early summer they invariably increase in yield of milk. This is a fact known to all dairymen, but the effect of the same

change on the quality of milk is not so well understood. Probably it is the general belief that the early summer pasture tends to produce a milk less rich in fat than the barn feed. The records of the University herd throw some light on the effect of this change in feed both on the quantity and quality of the milk. In considering these records, however, it should be borne in mind that nearly all the cows are fresh in milk in the early fall and are therefore so near to the end of the lactation period that most of them are dried off within six weeks to two months after they are turned to pasture. Under these conditions it is not to be expected they would show so much variation on a radical change of food as though they were fresh just before the change. Up to the time of going to pasture the cows receive an abundant ration of corn silage, mixed or clover hay, grain and roots, usually mangel wurtzels. On going to pasture, this ration is discontinued entirely except for some grain and what little hay the cows will eat at milking time. About one third or one fourth as much grain is given as when on full stall feed except to such of the cows as are fresh in the spring which receive about as much as they will eat. If the pasture continues good the grain is taken entirely away from all except the fresh cows.

To compare the quantity of milk given under the two conditions above named, the daily average yield for each cow was determined for four separate periods, viz: the last three weeks before going to pasture; the first week at pasture; the first two weeks at pasture; and the three weeks following the first two at pasture. From these averages was found the daily increase or decrease per head for each of the three periods at pasture as compared with the period on barn feed. The per cent of fat for each cow was averaged for the same periods and the increase or decrease determined.

In the following table (V) are given the individual records of the variation in milk and per cent of fat for one year (1898) in order to show the method of comparison and how some cows increase while others decrease under seemingly the same conditions. There are also given the averages for all the cows for each year and for the six years during which this study is carried.

Some interesting data on this same point has been published

by the Vermont Agricultural Experiment Station * and their results are appended in the table, to be compared with the results found at this Station. The daily averages for the Vermont herds were compiled for two periods, viz: the last twenty days before going to pasture; and the twenty days following the first ten at pasture.

TABLE V.—EFFECT OF THE CHANGE FROM BARN TO PASTURE ON THE MILK YIELD OF INDIVIDUAL COWS FOR 1898.

Name of cow.	Date of calving.	Average for last 21 days on barn feed.	Average for first 7 days on pasture	Increase or decrease.	Average for first 14 days on pasture	Increase or decrease.	Average for 21 days after first 14 days on pasture	Increase or decrease.
Belle	Aug. '97	18.25	19.00	+ .75	19.50	+1.25	19.75	+1.50
Belva 2d	Sept. '97	25.75	25.00	— .75	25.25	— .50	25.50	— .25
Bertha 2d	Jan. '98	22.25	23.50	+1.25	22.75	+ .50	24.75	+2.50
Cherry	Oct. '97	18.75	19.75	+1.00	19.75	+1.00	19.00	+ .25
Dora	Dec. '97	39.25	43.00	+3.75	42.75	+3.50	41.50	+2.25
Emma	Aug. '97	20.75	19.50	—1.25	21.25	+ .50	20.50	— .25
Garnet St. Lambert	Oct. '97	15.50	17.50	+2.00	17.25	+1.75	14.00	—1.50
Gem Valentine	Oct. '97	17.75	18.50	+ .75	19.00	+1.25	18.75	+1.00
Glista 4th	Sept. '97	28.75	30.25	+1.50	30.75	+2.00	28.75	.00
Glista Netherland	May '97	21.75	24.25	+2.50	24.50	+2.75	20.00	—1.75
Jennie 2d	Oct. '97	17.00	15.75	—1.25	14.25	—2.75	15.50	—1.50
Julia	Oct. '97	28.00	27.50	— .50	27.50	— .50	23.75	—4.25
Mabel 2d	Nov. '97	22.75	24.75	+2.00	24.75	+2.00	23.50	+ .75
May 2d	Sept. '97	22.75	25.00	+2.25	25.00	+2.25	25.25	+2.50
Mollie	Sept. '97	30.75	32.50	+1.75	33.00	+2.25	31.50	+ .75
Ruth	Nov. '97	22.50	21.00	—1.50	20.75	—1.75	20.50	—2.00
Valerie St. Lambert	Sept. '97	13.00	15.00	+2.00	14.75	+1.75	18.00	+5.00
Avg. of herd				+ .96		+1.01		+ .29

* Third, fourth, sixth and seventh Annual Reports.

VARIATION IN PER CENT OF FAT FOR SAME PERIODS.

Name of cow.	Average for last 21 days on barn feed.	Average for first 7 days on pasture	Increase or decrease.	Average for first 14 days on pasture	Increase or decrease.	Average for 21 days after first 14 days on pasture	Increase or decrease.
Belle	4.43	4.60	+.17	4.50	+.07	4.13	—.30
Belva 2d	3.28	3.40	+.12	3.18	—.10	3.33	+.05
Bertha 2d	4.72	4.20	—.52	4.32	—.40	4.37	—.35
Cherry	5.13	5.20	+.07	5.23	+.10	4.98	—.15
Dora	2.80	3.00	+.20	3.05	+.25	2.88	+.08
Emma	3.20	3.55	+.35	3.48	+.28	3.20	.00
Garnet St. Lambert	5.42	5.00	—.42	5.05	—.37	4.63	—.79
Gem Valentine	5.13	5.05	—.08	4.93	—.20	4.98	—.15
Glista 4th	3.47	3.20	—.27	3.38	—.09	3.35	—.12
Glista Netherland	3.18	3.50	+.32	3.48	+.30	3.13	—.05
Jennie 2d	4.33	4.60	+.27	4.45	+.12	4.75	+.42
Julia	3.40	3.65	+.25	3.23	—.17	3.50	+.10
Mabel 2d	3.97	4.20	+.23	4.23	+.26	3.90	—.07
May 2d	2.98	2.95	—.03	3.08	+.10	2.92	—.06
Mollie	3.23	3.15	—.08	3.05	—.18	3.17	—.06
Ruth	2.80	2.90	+.10	3.00	+.20	3.27	+.47
Valerie St. Lambert	5.47	4.80	—.67	4.95	—.52	5.47	.00
Average of herd			+.00		—.02		—.06

AVERAGE DAILY INCREASE OR DECREASE IN YIELD OF MILK AND PER CENT OF FAT AFTER COWS WERE TURNED TO PASTURE.

Year.	No. of Cows.	Milk.			Per cent of Fat.		
		For first 7 days.	For first 14 Days.	For 21 Days after First 14 Days.	For first 7 Days.	For first 14 Days.	For 21 Days after First 14 Days.
1892	20	— .46	+ .21	+ .26	+.16	+.24	+.03
1893	16	— .44	+1.42	+1.20	+.06	+.07	—.22
1894	18	+1.24	+1.46	— .85	+.07	——	—.17
1895	19	+ .83	+1.21	—1.90	+.07	—.06	—.01
1896	15	+ .50	+ .03	—1.67	+.46	+.47	+.17
1898	17	+ .96	+1.01	+ .29	.00	—.02	—.06
Av. of all	105	+ .43	+ .90	— .45	+.13	+.13	—.04

VERMONT AGRICULTURAL EXPERIMENT STATION.

Year.	No. of Cows.	When fresh in Milk.	Average for 20 days after 1st 10 days. Lbs. milk.	Average for 20 days after 1st 10 days. Per cent fat.
1889	10	Mostly Fall	+3.50	—.18
1890	4	Fall	+4.80	+.02
1890	6	Fall	+1.30	+.46
1890	81	Spring	+8.80	+.14
1893	14	————	+1.30	+.21
1894	21	————	+2.75	+.37
Av. of all	136		+3 75	+.17

The results with the University herd show that more milk was given on pasture than on stall feed during the first two weeks after the change. The effect of pasture was more strongly felt the second week than the first. But during the three following weeks the average daily yield of milk fell back to nearly one-half pound below that for the last three weeks in the barn. In the per cent of fat there was much the same general result, a slight increase during the first two weeks at pasture and then a falling balk to practically the same per cent as was found under barn conditions. There was more or less variation from year to year, some years showing a decrease where others showed an increase, but the majority show much the same result as is found in the average of all.

The Vermont herds show a much greater increase, especially in yield of milk than the University herd. The greatest increase was for the 81 cows whose daily average was 8.8 pounds greater on pasture than when in the barn. These cows were not owned by the station, and their barn feed was much less nutritious than the pasture ration. This condition together with the fact that they were fresh in the spring accounts for the great increase after the change. The six cows in the year 1890, which showed an average daily increase of 1.3 pounds, received a less nutritious ration in the barn than was supplied by the pasture. The barn ration of all the other cows consisted of a liberal allowance of grain, hay and silage, and was as nutritious as the pasture. However, when the cows were turned to pasture, this barn feed

was continued liberally, the cows standing in the barn every night. Comparing these records with those of the University herd for a similar period we find no case where the average increase for the herd equals that for the Vermont herds. In only one year (1893) does it approximate thereto and then only for the two lowest averages found in Vermont. The food conditions of the University herd have been given above, where it will be noticed that the barn ration must be fully as nutritious as pasture. Thus far the conditions correspond with those of the Vermont Station. But on turning to pasture the latter kept up the rich barn food while we eliminated nearly all of it, and herein may lie the cause of difference in results. The great increase of the 81 cows is the natural sequence of a change of fresh milkers from poor, dry feed to abundant succulent food, and cannot be justly compared with our conditions.

As regards quality of milk the Vermont records also show a greater increase in per cent of fat than was found for similar periods at this Station. During practically the same period after going to pasture our cows show nearly the same per cent of fat as when in the barn, while the Vermont herds show an increase of .17 per cent. Whether the differences in food conditions would account for this it is difficult to say.

Summing up, then, the comparison of records of the two Stations, and throwing out of the consideration the 81 cows, we have three varieties of conditions. First, 105 University cows changing from a rich barn ration to pasture by day and night with most of the former ration discontinued. Second, 39 Vermont cows changing from a rich barn ration to pasture by day with as much of the former ration continued as they will eat during the night. Third, six Vermont cows changing from a relatively poor barn ration to pasture by day with the same continuation of the former ration as in the second case. As results we have for the first case, a decrease in quantity and quality of milk after fourteen days of pasture; for the second and third cases, an increase in the quantity and quality of milk after ten days of pasture. This summary takes for granted that the length of time in milk is practically the same for all the cows. In the University herd it is found that some spring cows show no more increase in milk on going to pasture than do some fall cows.

COST OF MILK PRODUCTION.

During the year beginning January 15, 1892, and ending January 14, 1893, an accurate record was kept of the amount of food consumed by each cow as well as the amount of milk produced. From this record there was calculated the cost of producing milk and butter fat by each individual cow and the average cost for the herd. Owing to the fluctuation in price of feeds the cost of production then and now would differ even though conditions were otherwise the same. However, this variation in cost would occur between shorter periods owing to the same cause, and thus it does not seem out of place to publish in these pages the results of the experiment of 1892. Another reason for presenting them here is that the Bulletin in which they were originally published (No. 52) is out of print and so not accessible to the public. Accordingly we reprint here the more salient points and observations contained in that Bulletin.

In conducting this experiment it was the aim to feed a ration that would be eaten up fairly clean by all the cows. The foods used during the winter were hay, silage, roots, wheat bran, cotton-seed meal and corn meal. Only very slight variations were made from this list of foods. In the summer the cows had pasture of good quality and a grain ration, for the most of the time, of wheat bran and cotton-seed meal, supplemented with soiling crops when the pastures became dry.

The hay used was clover hay of a fair quality grown upon a wheat stubble and having a considerable proportion of volunteer wheat mixed with it, which was not readily eaten by the cows. The silage was made from Pride of the North corn grown in hills carrying a fair crop of ears. It was well preserved and of good quality. The roots used were almost wholly mangel wurtzels of medium size and good quality. The grain ration in January, February, March and April, 1892, was made up of a mixture of 300 pounds of bran, 200 pounds of cotton-seed meal and 60 pounds of corn meal. The corn silage crop of 1892 had considerably more grain than that of 1891, consequently, in November and December, 1892, and the first half of January, 1893, the corn meal was left out of the grain ration and three parts of bran and

two parts of cotton-seed meal were fed. During the time the cows were at pasture the grain ration was made up of three parts bran and one part cotton-seed meal. The daily winter ration was as follows :

For the larger cows.	*For the smaller cows.*
15 lbs. hay.	10 lbs. hay.
50–55 lbs. silage.	40–45 lbs. silage.
10 lbs. roots.	10 lbs. roots.
8 lbs. grain.	8 lbs. grain.

The only exceptions made to this were that Freddie and Puss, during January, February and March, 1892, had ten pounds of grain instead of eight. The summer grain ration was four pounds per cow except during the month of June when one-half of the cows received no grain whatever. The cows while dry were fed no grain at all, the remainder of the ration being unchanged. In the latter part of the summer, particularly in the months of August and October, the pastures became very short and were supplemented in August with second growth clover, cut and carried to the cows, and in October with corn stalks. These were in every case weighed and charged to the cows consuming them. In making up the cost of the food consumed the following scale of prices was used, based as far as possible upon the market prices in Ithaca :

Hay	\$ 9.00 per ton
Silage	1.75 per ton
Roots	2.00 per ton
Wheat bran	18.00 per ton
Oats	.35 per bu.
Cotton-seed meal	25.00 per ton
Corn meal	20.00 per ton
Corn stalks	3.00 per ton
Grass, cut and carried to cows	1.75 per ton
Pasture, exclusive of grain and silage crops	.30 per w'k

In Table VI is given the cost of food consumed by each animal ; the total number of pounds of milk and fat produced and the cost of a hundred pounds of milk and one pound of fat for each individual and the average for the whole. The average cost of food consumed was \$45.25 ; the highest for any one cow

TABLE VI.—COST OF FOOD, MILK AND FAT.

Cow.	Cost of food consumed during the year.	Pounds of milk produced.	Cost of 100 pounds of milk.	Pounds of fat produced.	Cost of one pound of fat.
Beauty	$44.24	8,028.50	$ .55	391.62	**$.115**
Belva	47.65	9,739.75	.49	309.19	**.155**
Bertha	42.00	4,743.25	.89	233.63	**.18**
Carrie	49.07	6,008.50	.82	219.34	**.225**
Cora	38.74	6,214.50	.62	326.68	**.12**
Daisy	41.24	2,829.75	1.48	159.02	**.26**
Freddie	52.06	11,165.00	.47	417.97	**.125**
Gazelle	39.96	5,670.50	.70	285.10	**.14**
Gem Valentine	36.24	3,387.75	1.07	197.33	**.185**
Glista	46.51	6,323.50	.74	224 71	**.21**
Glista 2d	43.80	5,136.00	.85	160.79	**.27**
Jennie	43.66	5,785.75	.75	294.30	**.15**
May	44.34	5,458.50	.81	195.31	**.225**
Mollie	45.98	7,757.25	.59	260.34	**.175**
Pearl	47.44	9,003.25	.53	299 07	**.16**
Pet	43.12	9,776 50	.44	330.59	**.13**
Puss	47.87	10,417.00	.46	302.93	**.16**
Ruby	48.63	7,955.00	.61	282 35	**.17**
Shadow	53.38	8,655.50	.62	382.77	**.14**
Sue	49.08	10,754.00	.46	439.37	**.11**
Total	$905.01	144,809.75		5,712.41	
Average	45.25	7,240.50	$.625	285.62	**$.158**

was $53.38 for the cow Shadow; the lowest $36.24 for Gem Valentine. The average cost of 100 pounds of milk was almost exactly 62½ cents; the highest for any one cow being $1.48 for Daisy; the lowest 44 cents for Pet. If we consider milk to be worth $1.00 per hundred weight at the barn two of the cows produced milk at a loss, Daisy and Gem Valentine. The average cost of butter fat was 15.8 cents; the highest 27 cents for Glista 2d; the lowest 11 cents for Sue. If we should consider fat to be worth 30 cents per pound, which is a little more than an equivalent of 25 cents a pound for butter, we should have no cows that produced fat at a loss for food consumed.

GENERAL SUMMARY AND CONCLUSIONS.

A good grade herd can be bred up from a herd of ordinary cows by the use of first-class thoroughbred sires and a careful selection of the best heifers.

By breeding in this way the University herd has increased in milk production from an average of 3,000 pounds per cow in 1874 to an average of 7,575 pounds in 1898.

It pays to select heifers from the best cows as well as to use only well bred bulls. Milk such heifers at least one year and then retain only those which give promise of being profitable producers.

The greatest production for one lactation period was by Ruby in 64 weeks, 16089.5 pounds of milk, and 531.32 pounds of fat, equivalent to 625 pounds of butter containing 85 per cent fat.

The average production for seven years was 7330 pounds of milk, 275 pounds of fat and 3.76 per cent fat. The average for each year varied from 6,875 pounds of milk in 1892–3, and 266 pounds of fat in 1895–96 to 7,575 pounds of milk in 1897–8, and 292 pounds of fat in 1893-94.

The average gain in production of milk as the cows increased in age was 5 per cent from two to three-year-olds, 18 per cent from three to four-year-olds, and 15.3 per cent from four-year-olds to full aged cows.

The average gain in production of butter fat was 5.5 per cent from two to three-year-olds, 17 per cent from three to four-year-olds, and 13.6 from four-year-olds to full aged cows.

Beginning with the third week after calving and dividing the remainder of the lactation into periods of four weeks, and then considering the average daily yield of milk of all the cows for the first period as 100 there was a gradual decrease in milk flow to 55 during the eleventh period.

Calculating the average per cent of fat in like manner, there was a decrease to 96 in the second period and then a gradual increase to 106 during the eleventh period.

Speaking in other terms there was an average decrease in yield of milk as lactation advanced, of about five per cent from each period of four weeks to the next. In per cent of fat there was

an average increase of about one-half of one per cent from month to month.

As a rule, a cow will produce more butter during the first few weeks of a lactation period than at any equal subsequent time during the same lactation.

The general effect of the change from barn to pasture was an increase in both milk flow and per cent of fat for the first two weeks, and for the next three weeks a slight decrease in milk and per cent of fat below the daily average for the last three weeks in the barn.

During the year 1892 twenty cows produced milk for 62½ cents per hundred weight and fat for about sixteen cents per pound for the food consumed.

In general, the cows consuming the most food produced both milk and fat at the lowest rate.

Bulletin 170. **May, 1899.**

Cornell University Agricultural Experiment Station,

ITHACA, N. Y.

ENTOMOLOGICAL DIVISION.

EMERGENCY REPORT

ON

TENT CATERPILLARS.

By M. V. SLINGERLAND

PUBLISHED BY THE UNIVERSITY,

ITHACA, N. Y.

1899.

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The regular bulletins of the Station are sent free to all who request them.

CORNELL UNIVERSITY, ITHACA, May 22, 1899.

HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

Sir: Responding to your request of the 15th inst., for suggestions as to the controlling of the forest caterpillar, which has appeared in such numbers in Scoharie and Otsego Counties, I herewith submit a bulletin of advice by Professor Slingerland. Professor Bailey has already sent Mr. H. P. Gould, our expert in spraying, into the affected districts. It is now too late, however, to avert the calamity of this year, but it is hoped that the people may be awakened for action during the coming winter and next spring. This emergency bulletin is submitted to be issued under Chapter 430 of the Laws of 1899.

I. P. ROBERTS,
Director.

TENT CATERPILLARS.

Commissioner of Agriculture Wieting, reports in a recent letter to Director Roberts that many orchards, in the eastern part of the State are overrun with forest tent caterpillars. The writer is also receiving daily from village authorities in eastern New York, appeals for aid in destroying the vast hordes of the hairy caterpillars of the same insect which are defoliating thousands of beautiful shade trees, especially maples, in many village streets. A trip to Oneonta convinced us that an alarming state of affairs exists wherever this insect occurs in such almost incredible numbers as we saw on many of Oneonta's fine maple shade trees. Thousands of the shade trees in many New York villages are doomed unless prompt measures are taken to destroy the caterpillars, or "maple worms," as many call them. We began making observations upon this insect last year, when it stripped the leaves from many maple sugar groves in our State, and we have been watching it this spring, when it seems to be more numerous and destructive all through the State than in many years.

Our studies are not yet completed, but there is such a general call for information regarding the insect that this preliminary report, or emergency bulletin, has been hastily prepared to meet the demand. We expect to publish a full account of the forest and the apple tent caterpillars, and will also discuss cankerworms in the near future.

The Apple-tree Tent Caterpillar.

Many are familiar with the common apple tent caterpillar (shown in figure 101) its work, and especially its large silken tent which a colony of the caterpillars spin and use as a nest or home. These tent caterpillar nests have been altogether too conspicuous objects in the nearby landscape in most parts of our State during the past two years. It is the work of only a few moments to wipe out with a rag, or burn out one of these tents with its writhing mass of worms. The sooner this operation is performed after the nest is begun, the easier and more effectual will it be. Wild cherry trees along roadsides should be destroyed, for they are a favorite breeding-place for the apple tent caterpillars, fall web worms, and other injurious insects.

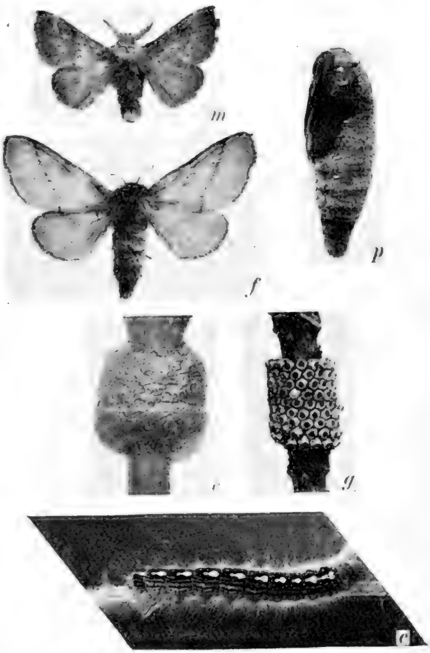
Our orchardists should learn to familiarize themselves with the egg-masses of the apple tent caterpillar, for one of the easiest and most effectual methods of controlling the pest is to collect and burn these egg-masses at any time between August and the following April; the egg-mass is very similar to, but a little larger than that of the forest tent caterpillar shown at *e* in figure 102. Pay the boys and girls a few cents for each score or hundred of the egg-masses they collect; you will be doubly repaid when spring opens by a decided scarcity of caterpillar nests to wipe or burn out. Those who spray their orchards thoroughly with Bordeaux mixture, to which Paris green or some similar poison has been added at the rate of one pound to 150 gallons of the Bordeaux, report little trouble in controlling apple tent caterpillars by this method alone. Caterpillar nests are usually a scarce article in orchards which have had three thorough applications of the above spray. The first application should be made just before the blossoming period, when the caterpillars are very small and require but little poison to kill them; the second spraying should follow as soon as the blossoms have fallen, and a third application is usually necessary and advisable about a week or ten days after the second. Unless canker-worms occur in extraordinary numbers in an orchard,

101.—*A trio of Apple Tent Caterpillars, natural size.*

not many of them will live through the three applications above specified, if they are thoroughly made, and the same statements will apply to the forest tent caterpillars.

THE LIFE-STORY OF THE TENT CATERPILLARS.

In order to combat an insect pest the most effectively, one should know its life-story. The story of the lives of the apple and forest tent caterpillars may be briefly told by the aid of the pictures in figure 102. These two tent caterpillars are distinct kinds of insects but are very nearly related to each other and each has practically the same general life-history, differing only in some details of habits. The story of the Apple-tree Tent Caterpillar (*Clisiocampa americana*) has been interestingly told in the Teacher's Leaflet No. 5, which anyone can get free by applying to the Bureau of Nature-Study, College of Agriculture, Ithaca, N. Y.



102.—*The life-story of the Forest Tent Caterpillar. m, male moth; f, female; p, pupa; e, egg-ring recently laid; g, hatched egg-ring; c, caterpillar. Moths and caterpillars are natural size, and eggs and pupa are slightly enlarged.*

At the date of writing (last week in May), the forest tent caterpillars (*Clisiocampa disstria*) are nearly full grown; the picture at *c* in figure 102 was recently taken from life. In about two weeks, or early in June, the caterpillars will be seen wandering about seeking a suitable place to undergo their wonderful transformations. They may select a leaf on or under the tree on which they fed, as did the one shown in the frontispiece, or some angle in your house or rail-fence may afford a more suitable place. Here the caterpillar will begin to spin about itself a white

shroud or cocoon, composed of silken threads, in which are mixed the hairs from its own body and the whole is given a powdery appearance by the caterpillar ejecting a liquid which becomes a yellowish powder upon drying. A cocoon is shown in figure 103.

Within this cocoon the caterpillar soon changes to the curious brown object—a pupa—shown at *p* in figure 102. In about ten days or two weeks after the cocoon is spun, or during the latter part of June, there emerges from it the adult insect—a buff-brown colored moth marked with a slightly darker band across each front wing; *m* and *f* in figure 102 represent the male and female moth respectively. The moths fly mostly at night and are often attracted to lights.

Soon after emerging, the female moths deposit their eggs in masses of about two hundred each around the smaller twigs, as shown at *e* in figure 102. The eggs are covered with a varnish-like substance; at *g* in figure 102 is shown an old, hatched egg-mass with the varnish-like coating worn off. The eggs thus deposited early in July will remain unhatched until the following April. Thus there is but one brood of the caterpillars in a year.

103.—*Cocoon spun by a Forest Tent Caterpillar in a maple leaf, natural size.*

A very important difference in habit between the forest and the apple tent caterpillar should here be emphasized. It is this: A colony or family of forest tent caterpillars hatching from the same egg-cluster, like their near relatives, work and live together during most of their life *but they never make any tent or nest.* The only approach to a web made by the forest tent caterpillars is a thin carpet spun on the bark or sometimes over several terminal leaves on which the whole family usually rest in a cluster (as shown in figure 104) during the day or when they are shedding their skins.

METHODS OF COMBATING THE FOREST TENT CATERPILLAR.

Fortunately both the apple and the forest tent caterpillars are preyed upon by many enemies, including insects, spiders, toads and birds. Where the forest tent caterpillars confine their work to their native haunts—the forest trees—we must depend largely upon these natural enemies to hold the insect in check. That these enemies are capable of doing this is evidenced by the fact that this insect usually appears in alarming numbers only at long intervals and its outbreaks usually last only a few years, as their enemies soon reduce their numbers to the normal. We visited several maple "sugar bushes" last year where the caterpillars had just finished stripping the foliage from all the trees, and we never saw so many parasitic foes: the little Ichneumons and Tachnia flies were surprisingly numerous and busy getting in their deadly work on the caterpillars. Most owners of "sugar bushes" will have to depend on these little friends to check the depredations of the forest tent caterpillars, because it would usually be too expensive a job for an individual owner to undertake to combat the pest in his sugar grove. We hope and believe that the enemies of the caterpillars can be depended upon to get the upper hand and control the pest in the forests and sugar groves of New York in a year or two.

Where the forest tent caterpillars are present in alarming numbers in fruit or shade trees, however, the case is very different, and man should take prompt measures to check their ravages. In orchards the methods of gathering the egg-clusters and spraying with Bordeaux and Paris green, discussed on a previous page, will usually control the forest tent caterpillars. The presence of these caterpillars is not so readily discovered because they erect no tent or "signboard" in the tree as does the apple tent caterpillar. The two kinds of caterpillars often occur in the same tree.

The control of the forest tent caterpillar on village shade trees is a special problem, but not a difficult one, we believe. Enlist the aid of the school teachers, and the school children will soon become an invaluable army to help in protecting the trees. Let a few public spirited citizens or the village Board offer a prize to

those pupils who collect over a certain number, say 1,000 or 10,000 of the unhatched egg-clusters at any time between August 1st and April 1st of the following year; or pay the children a certain sum, a few cents for every hundred unhatched egg-clusters collected. All egg-clusters collected should be burned. The rivalry between the children will soon spread to rivalries between schools and the result will be that the number of the caterpillars will be reduced to the minimum by a single season's crusade of the children; and what may be of more value still is the fact that the teachers, children, and many citizens will get lots of fun out of the warfare and all cannot help but learn a very instructive lesson in Mother Nature's ways.

The above suggestion is not a theory, for just such a crusade has been successfully carried out even in so large a city as Rochester, N. Y. We believe there is no cheaper and more instructive method of controlling these forest tent caterpillars in village shade trees. Begin the warfare in August or September, 1899, or better, after the leaves have fallen so that the eggs can be more easily seen on the twigs, and keep it up until the last egg-cluster is burned before April 1st, 1900. Let the beautiful and valuable shade trees begin the new century free from the devastating caterpillars.

Shade trees can be, and have been, sprayed with a poisonous mixture and these forest tent caterpillars killed thereby. But the spraying must be done early in the spring after the little caterpillars hatch, when the first leaves are unfolding; and to spray large shade trees requires very expensive ($250.00 at least) apparatus, and experienced men to operate it. It is the nastiest kind of work, and the chemicals would be quite an item. Hence it is doutful if spraying could be successfuly employed to control these caterpillars in many villages. When the caterpillars get half or two-thirds grown as they are now (last week in May) they are so large that it would be a very expensive matter to feed them enough Paris green to kill them. We believe it would be cheaper, easier and more effectual, to either enlist the children, or to carry on a vigorous warfare against the nearly full grown caterpillars during the latter part of May and the first week or two in June along the following lines:

Colonies of the caterpillars can be seen at almost any time of day clustered together on the bark of the trunk or large branches of the infested trees. Such a cluster of caterpillars is shown in figure 104. The apple tent caterpillar may usually be found in its nest during the day, but its forest relative makes no such retreat or home. Where these clusters of caterpillars occur in reach on the trunks of the trees it is an easy matter to sweep them off and crush them. It is also an easy matter to dislodge the clusters occurring high up in the tree on the branches. One has simply to climb the tree with a padded mallet and suddenly *jar* (shaking will not do) the branches on which the caterpillars are clustered, when nearly every caterpillar will drop to the ground as if shot, some spinning down by a silken thread, which, however, they seem to be unable to ascend as a canker-worm does. One should not be satisfied with jarring the caterpillars onto the ground, but a sheet or canvass should have been previously spread beneath the tree, and someone employed to at once sweep the caterpillars into some receptacle where they can be burned or otherwise destroyed. Two men could thus remove and destroy nearly all the forest tent caterpillars on a large shade tree in a few minutes, and thus stop the breeding of the insect for the next

104.—*A family of Forest Tent Caterpillars resting during the day on the bark, about one-third natural size.*

season. This jarring method is also applicable to orchards, and is in fact the only practicable method to reach the caterpillars after they are half or two-thirds grown, or after May 20th in most localities in our state. The method can be practiced by individual owners of fruit or shade trees, but where village shade trees are infested, we would recommend that the village authorities hire two or more men, equip them with padded mallets, brooms, and sheets, and have them make a business of examining every shade tree and killing the caterpillars. All of the shade trees in a village could be thus gone over in a few days and millions of the caterpillars destroyed before they can transform. A second scrutiny of the trees by the same gang of men a few days later would doubtless pay. One hundred dollars expended in this way, *now*, by a village, to combat these caterpillars would not be felt by the individual taxpayers, and would doubtless result in saving the lives of shade trees worth ten times this amount. It would not be advisable to trust to individual property owners to jar their trees, for many would not do it, and thus would breed a crop of the caterpillars for their neighbors the next season.

Cotton batting, coal tar, or similar bands put on trees to prevent the caterpillars from crawling up, will avail but little in reducing their numbers, for only those which fall from the trees or happen to wander from the defoliated trees will thus be kept from going up.

These hordes of tent caterpillars which are now ravaging shade and fruit trees in our state can be readily controlled if prompt and intelligent action be taken.

M. V. SLINGERLAND.

APPENDIX II.

Detailed Statement of Receipts and Expenditures of the Cornell University Agricultural Experiment Station, for the fiscal year ending June 30th, 1899.

RECEIPTS.

FROM AGRICULTURAL AND HORTICULTURAL DIVISIONS.

1899		
June 30.	Products sold, hauling coal, etc.	$ 627 32

EXPENDITURES.

FOR SALARIES.

1898		
July 31.	I. P. Roberts, Director, 1 mo.	$ 125 00
" 31.	L. H. Bailey, Horticulturist, 1 mo.	125 00
" 31.	H. H. Wing, Asst. Prof. Dairy Husbandry, 1 mo.	125 00
" 31.	G. F. Atkinson, Botanist, 1 mo.	83 33
" 31.	G. W. Cavanaugh, Assistant Chemist, 1 mo.	83 33
" 31.	L. A. Clinton, Assistant Agriculturist, 1 mo.	100 00
Aug. 31.	I. P. Roberts, Director, 1 mo.	125 00
" 31.	L. H. Bailey, Horticulturist, 1 mo.	125 00
" 31.	H. H. Wing, Asst. Prof. Dairy Husbandry, 1 mo.	125 00
" 31.	G. F. Atkinson, Botanist, 1 mo.	83 33
" 31.	G. W. Cavanaugh, Assistant Chemist, 1 mo.	83 33
" 31.	L. A. Clinton, Assistant Agriculturist, 1 mo.	100 00
Sept. 30.	I. P. Roberts, Director, 1 mo.	125 00
" 30.	L. H. Bailey, Horticulturist, 1 mo.	125 00
" 30.	H. H. Wing, Asst. Prof. Dairy Husbandry, 1 mo.	125 00
" 30.	G. F. Atkinson, Botanist, 1 mo.	83 33
" 30.	G. W. Cavanaugh, Assistant Chemist, 1 mo.	83 33
" 30.	L. A. Clinton, Assistant Agriculturist, 1 mo.	100 00
Oct. 31.	I. P. Roberts, Director, 1 mo.	125 00
" 31.	L. H. Bailey, Horticulturist, 1 mo.	125 00
" 31.	H. H. Wing, Asst. Prof. Dairy Husbandry, 1 mo.	125 00
" 31.	G. F. Atkinson, Botanist, 1 mo.	83 33
" 31.	G. W. Cavanaugh, Assistant Chemist, 1 mo.	83 33
" 31.	L. A. Clinton, Assistant Agriculturist, 1 mo.	100 00
" 31.	E. A. Butler, Clerk, 1 mo.	60 00
Nov. 30.	I. P. Roberts, Director, 1 mo.	125 00
" 30.	H. H. Wing, Asst. Prof. Dairy Husbandry, 1 mo.	125 00
" 30.	L. H. Bailey, Horticulturist, 1 mo.	125 00
" 30.	M. V. Slingerland, Assistant Entomologist, 1 mo.	135 00
" 30.	G. F. Atkinson, Botanist, 1 mo.	83 33
" 30.	G. W. Cavanaugh, Assistant Chemist, 1 mo.	83 33
" 30.	L. A. Clinton, Assistant Agriculturist, 1 mo.	100 00
" 30.	E. A. Butler, Clerk, 1 mo.	60 00

Amount carried forward, $3,463 30

		Amount brought forward	$3,463 30
Dec.	20.	M. V. Slingerland, Assistant Emtomologist ½ mo. (Last half October, 1898)	67 50
Dec.	31.	I. P. Roberts, Director, 1 mo	$ 125 00
"	31.	L. H. Bailey, Horticulturist, 1 mo	125 00
"	31.	H. H. Wing, Asst. Prof. Dairy Husbandry, 1 mo	125 00
"	31.	M. V. Slingerland, Assistant Entomologist, 1 mo	135 00
"	31.	G. F. Atkinson, Botanist, 1 mo	83 33
"	31.	G. W. Cavanaugh, Assistant Chemist, 1 mo	83 33
"	31.	L. A. Clinton, Assisant Agriculturist, 1 mo	100 00
"	31.	E. A. Butler, Clerk, 1 mo	60 00
1899			
Jan.	31.	I. P. Roberts, Director, 1 mo	125 00
"	31.	L. H. Bailey, Horticulturist, 1 mo	125 00
"	31.	H. H. Wing. Asst. Prof. Dairy Husbandry, 1 mo	125 00
"	31.	M. V. Slingerland, Assistant Entomologist, 1 mo	135 00
"	31.	G. F. Atkinson, Botanist, 1 mo	83 33
"	31.	G. W. Cavanaugh, Assistant Chemist, 1 mo	83 33
"	31.	L. A. Clinton, Assistant Horiculturist, 1 mo	100 00
"	31.	E. A. Butler, Clerk, 1 mo	60 00
Feb.	28.	I. P. Roberts, Director, 1 mo	125 00
"	28.	L. H. Bailey, Horticulturist, 1 mo	125 00
"	28.	H. H. Wing, Asst. Prof. Dairy Husbandry, 1 mo	125 00
"	28.	M. V. Slingerland, Assistant Entomologist, 1 mo	135 00
"	28.	G. F. Atkinson, Botanist, 1 mo	83 33
"	28.	L. A. Clinton, Assistant Agriculturist, 1 mo	100 00
"	:8.	E. A. Butler, Clerk, 1 mo	60 00
Mar.	31.	I. P. Roberts, Director, 1 mo	125 00
"	31.	L H Bailey, Horticulturist, 1 mo	125 00
"	31.	H. H. Wing, Asst. Prof. Dairy Husbandry, 1 mo	125 00
"	31.	M. V. Slingerland, Assistant Entomologist, ½ mo.	67 50
"	31.	G. F. Atkinson, Botanist, 1 mo	83 33
"	31.	L. A. Clinton, Assistant Agriculturist, 1 mo	100 00
"	31.	E. A. Butler, Clerk, 1 mo	60 00
Apr.	30.	I. P. Roberts, Director, 1 mo	125 00
"	30.	L. H. Bailey, Horticulturist, 1 mo	125 00
"	30.	H. H. Wing, Asst. Prof. Dairy Husbandry, 1 mo	125 00
"	30.	G. F. Atkinson, Botanist, 1 mo	83 33
"	30.	G. W. Cavanaugh, Assistant Chemist, 1 mo	83 33
"	30.	L. A. Clinton, Assistant Agriculturist, 1 mo	100 00
May	31.	I. P. Roberts, Director, 1 mo	125 00
"	31	L. H. Bailey, Horticulturist, 1 mo	125 00
"	31.	H. H. Wing, Asst. Prof. Dairy Husbandry, 1 mo	125 00
"	31.	G. F. Atkinson, Botanist, 1 mo	83 33
"	31.	G. W. Cavanaugh, Assistant Chemist, 1 mo	83 33
"	31.	L. A. Clinton, Assistant Agriculturist, 1 mo	100 00
June	30.	I. P. Roberts, Director, 1 mo	125 00
"	30.	L. H. Bailey, Horticulturist 1 mo	125 00
"	30.	H. H. Wing, Asst. Prof. Dairy Husbandry, 1 mo	125 00
"	30.	G. F. Atkinson, Botanist, 1 mo	83 37
"	30.	G. W. Cavanaugh, Assistant Chemist, 1 mo	83 37
"	31.	L. A. Clinton, Assistant Agriculturist, 1 mo	100 00
		Total for Salaries	$8,568 34

FOR BUILDINGS.

1899			
June	7.	Forest City Plumbing Co., Sewer for Insectary	$ 48 75

FOR OFFICE AND PRINTING.

1898			
July	2.	M. A Adsitt, 1 doz. carbon	$ 50
"	2.	M. A. Adsitt, Ink	1 20
"	2.	Andrus & Church, Pens	75
"	2.	Andrus & Church, Sundry Office supplies	4 68
"	13.	W. H. Lowdermilk & Co., Book on Manures	2 00
"	25.	Franklin Engraving and Printing Co., Halftone cuts	17 98
"	28.	U. S. P. O., Postage	20 00
"	30.	L. V. Maloney, Labor	43 33
Aug.	11.	W. F. Humphrey, 5 M. copies Bulletin No. 142 and plates	166 50
"	17.	U. S. P. O., Postage	25 00
"	31.	L. V. Maloney, Labor	45 00
"	30.	G. W. Tailby, Labor	12 44
Sept.	12.	M. A. Adsitt, Cleaning typewriter	5 66
"	12.	W. F. Humphrey, 20 M. copies Bulletin No. 150 and plates	307 55
"	12.	Andrus & Church, Pens and pencil holder	15
"	12.	M. Mandeville, Labor	31 25
"	21.	J. W. Halsey, Cartage	25
"	23	Andrus & Church, 500 postals and printing	6 25
"	30.	L. V. Maloney, Labor	43 33
Oct.	1.	C. B. Tailby, Labor	2 56
"	1.	G. W. Tailby, Labor	3 33
"	4.	W. F. Humphrey, 150 copies Eleventh Annual Report	87 84
"	11.	Ithaca Gas Co., Gas	16
"	11.	Andrus & Church, Labels	75
"	19.	M. A. Adsitt, Mimeograph ink	3 70
"	20.	U. S. P. O., Postage	25 00
"	31.	L. V. Maloney, Labor	43 33
"	31.	C. B. Tailby, Labor	5 60
"	31.	G. W. Tailby, Labor	6 62
Nov.	2.	W. Nuffort, Labor	3 53
"	8.	E. D. Norton, Printing 2 M. cards	7 00
"	8.	Ithaca Gas Co., Gas	64
"	14.	L. V. R. R., Freight and cartage	12 08
"	14.	W. F. Humphrey, 20 M. copies Bulletin No. 152	485 20
"	14.	U. S. Express Co., Expressage	75
"	15.	W. Nuffort, Labor	3 38
"	18	M. V. Slingerland, Traveling Expenses (A. A. A. C. & E. S. annual meeting)	31 65
"	21.	W. Nuffort, Labor	1 05
"	28.	Franklin Engraving & Printing Co., Halftone	3 00
"	30.	L. V. Maloney, Labor	43 33
Dec.	1.	G. W. Tailby, Labor	4 82
"	1.	W. F. Humphrey, 20 M. copies Bulletin No. 154	193 80
"	1.	L. V. R. R., Freight and cartage	3 81
"	3.	Cornell Co-Op., Sundry office supplies	44 66
"	3.	U. S. Express Co., Expressage	1 60
"	6.	U. S. P. O., Postage	25 00
"	7.	W. Nuffort, Labor	2 85
"	12.	U. S. Express Co , Expressage	25
"	12.	Ithaca Gas Co., Gas	3 52
"	20.	Andrus & Church, Postals and printing, etc	6 50
"	20.	W. S. More, 1 book "Dairy Fortunes"	1 00
"	21.	W. Nuffort, Labor	3 30
		Amount carried forward,	$1,795 43

		Amount brought forward	$1,795 43
Dec.	28.	W. F. Humphrey, 20 M. copies Bulletin No. 156	97 30
"	30.	L. V. Maloney. Labor	45 00
"	31.	Lovejoy Co., 3 electros	57
"	31.	Andrus & Church, 5 M. envelopes	6 75
"	31.	M. V. Slingerland, 2 Annual Reports	2 00
1899			
Jan.	11.	Ithaca Gas Co., Gas	3 45
"	11.	Cornell Co-Op., Sundry office supplies	9 53
"	18.	L. V. R. R. Co., Freight and cartage	1 94
"	24.	W. Nuffort, Labor	3 30
"	27.	Humphrey, 20 M. copies Bulletin No. 162	96 00
"	27.	Syndicate Press, 4 line cuts	6 54
"	31.	L. V. Maloney, Labor	43 33
"	31.	L. V. R. R. Co., Freight and cartage	5 89
Feb.	6.	Ithaca Gas Co., Gas	3 56
"	13.	A. A. A. C. & E. S., Membership fee	10 00
"	13.	*Ithaca Journal*, Advertisement for old reports	4 88
"	16.	International Printing Co., Publications	4 00
"	26.	L. V. R. R. Co., Freight and cartage	6 19
"	28.	Andrus & Church, Printing	1 00
"	28.	L. V. Maloney, Labor	40 00
Mar.	1.	Cornell Co-Op., Office supplies	8 00
"	6.	A. L. DeMund, Labor	10 10
"	9.	Ithaca Gas Co., Gas	1 00
"	18.	W. Nuffort, Labor	3 00
"	22.	Ithaca Gas Co., Gas	1 57
"	29.	W. Nuffort, Labor	5 10
Apr.	1.	Julia L. Seely, Labor	9 00
"	3.	C. B. Tailby, Labor	6 03
"	3.	G. W. Tailby, Labor	6 35
"	7.	Ithaca Gas Co., Gas	1 65
"	10.	I. P. Roberts, Traveling expenses	8 58
"	10.	Cornell Co-Op., Sundry office supplies	1 63
"	15.	W. Nuffort, Labor	4 50
"	30.	L. V. Maloney, Labor	41 66
May	6.	W. Nuffort, Labor	4 50
"	8.	Ithaca Gas Co., Gas	1 00
"	8.	Cornell Co-Op., Office supplies	2 90
"	12.	S. T. Shanks, Labor	3 55
"	26.	W. F. Humphrey, 20 M copies Bulletin No. 169	292 40
"	29.	W. Nuffort, Labor	3 00
June	7.	Cornell Co-Op., Sundry office supplies	7 58
"	7.	Ithaca Gas Co., Gas	1 14
"	8.	W H. Lyons, 4 paper weights	1 00
"	10.	W. Nuffort, Labor	30
"	30.	M. A. Adsitt, Stationery	4 50
"	19.	Ithaca Rubber Stamp Works, Box rubber type	1 50
"	28.	Andrus & Church, Pencils	28
		Total for Office and Printing	$2,618 48

FOR AGRICULTURAL DIVISION.

1898			
July	2.	U. S. Express Co., Expressage	50
"	2.	White & Burdick, Drugs	80
		Amount carried forward,	$ 1 30

		Amount brought forward	$ 1 30
July	2.	Jameison & McKinney, 1 hose connection	15
"	2.	J. M. Thorburn & Co., Seeds	27
"	2.	White & Burdick, Drugs	13 50
"	30.	U. S. P. O., Postage and envelopes	21 60
Aug.	1.	L. S. Harrington, Labor	13 80
"	1.	E. B. Cobb, Labor	4 00
"	1.	C. B. Tailby, Labor	12 87
"	1.	G. W. Tailby, Labor	16 22
"	1.	S. L. Sheldon, Photos	2 00
"	11.	White & Burdick, Drugs	6 00
"	13.	U. S. Express Co., Expressage	75
"	18.	J. M. Thorburn & Co., Seed	68
"	30.	C. B. Tailby, Labor	9 66
"	30.	L. S. Harrington, Labor	25 58
Sept.	7.	J. W. Halsey, Cartage	25
"	23.	Andrus & Church, Memorandum paper	2 13
"	23.	S. L. Sheldon, Photos	20
Oct.	11.	Stephens & Masters, 25 feet hose and coupling	4 73
"	17.	J. B. Lang, Labor on spraying machines	34 11
"	31.	J. L. Stone, Beet knife	95
"	31.	F. M. Huntoon, Labor	90
"	31.	C. W. Kresge, Labor	8 40
"	31.	L. S. Harrington, Labor	3 00
"	31.	S. Raub, Labor	12 30
"	31.	Cobb, Labor	14 44
Nov.	10.	E. McGillivray, Photographic supplies	3 70
"	10.	White & Burdick, 2 vat-thermometers	2 50
"	14.	Andrus & Church, paper sacks	1 10
"	15.	H. H. Wing, Traveling expenses	13 18
"	19.	George Small, Lumber for silo	49 75
"	19.	Andrus & Church, Stationery	4 75
"	30.	C. Kresge, Labor	31 50
"	30.	F. Huntoon, Labor,	30
"	30.	W. G. Cobb, Labor	13 85
"	30.	E. Cobb, Labor	6 13
"	30.	J. W. Smith, Shearing sheep	4 50
"	30.	J. L. Stafford, 6 pigs	7 50
Dec.	1.	S. L. Sheldon, Photos	4 73
1899			
Jan.	21.	E. Norton, Printing	3 75
Mar.	9.	Treman, King & Co., Tacks	10
Apr.	18.	Geo. H. Colvin, Seed potatoes	3 00
"	24.	J. Chatillon & Sons, 1 spring balance	2 50
"	26.	L. V. R. R., Freight and cartage	34
May	5.	S. L. Sheldon, 8 prints	2 00
June	1.	C. B. Tailby, Labor	3 96
"	1.	G. W. Tailby, Labor	4 40
"	1.	W. G. Cobb, Labor	8 92
"	1.	C. W. Kresge, Labor	38 42
"	1.	S. Brong, Labor	38 42
"	1.	George Taylor, Labor	38 42
"	10.	Barr Brothers, 1 copper dipper	1 25
"	30.	E. D. Norton, 300 postal cards printed	7 25
"	30.	G. Rankin & Son, Lamp shades	1 45
"	21.	W. G. Cobb, Labor	4 50
		Total for Agricultural Division	$511 96

FOR HORTICULTURAL DIVISION.

1898			
July	2.	Burns Bros., Blacksmithing	$ 2 40
"	2.	A. J. Calkins, Repairs on harness	6 20
"	2.	White & Burdick, Drugs	6 15
"	2.	Shady Hill Nurseries, Plants	1 35
"	2.	J. B. Lang, Labor and repairs	6 30
"	2.	J. W. Manning, Plants	3 75
"	2.	Andrus & Church, Sundry supplies	4 70
"	2.	U. S. Dept. Agriculture, Index cards	2 00
"	2.	J. Carbutt, 2 packages tablets	1 44
"	2.	B. F. White, Slides and photos	31 27
"	2.	C. U. Chemical Dept., Chemicals	2 78
"	3.	George Small, Lumber for forcing houses	20 79
"	28.	J. J. McGowan, Oats	20 96
"	28.	D. L. & W. R. R., Freight and cartage	45
"	30.	G. M. Lauman, Salary	50 00
Aug.	1.	Ira Grover, Labor	37 50
"	2.	F. K. Luke, Labor	13 00
"	11.	E. MacGillivray, Photographic supplies	3 62
"	11.	George Small, Boxes, etc	16 20
"	11.	Burns Brothers, Horseshoeing	6 00
"	11.	Syracuse Pottery Co., Flower pots	5 58
"	31.	G. N. Lauman, Salary	50 00
Sept.	6.	Ira Grover, Labor	37 50
"	12.	J. M. Thorburn & Co., Seeds	1 14
"	12.	Burns Bros., Horseshoeing	3 70
"	13.	Andrus & Church, Postals and printing	2 75
"	20.	A. D. MacGillivray, Lens	3 85
"	23.	Andrus & Church, Mounting paper	3 75
"	27.	U. S. Express Co., Expressage	60
"	30.	G. N. Lauman, Salary	50 00
Oct.	6.	U. S. Express Co., Expressage	1 50
"	7.	Ira Grover, Labor	37 50
"	22.	U. S. Express Co., Expressage	1 55
Nov.	2.	G. E. Buck, Peach trees	2 40
"	3.	Ira Grover, Labor	37 50
"	4.	U. S. Express Co., Expressage	1 95
"	5.	Fall Creek Milling Co., Bran	1 07
"	5.	F. E. Illston, Ice	4 45
"	8.	C. O. Voegelin, Labor	9 38
"	10.	E. MacGillivray, Plates	1 58
"	15.	U. S. Express Co., Expressage	70
"	19.	L. V. R. R. Co., Freight and cartage	1 13
"	30.	U. S. Dept. Agr., Index cards	2 05
Dec.	3.	Ira Grover, Labor	37 50
"	3.	U. S. Express Co., Expressage	25
"	7.	Wm. C. Baker, Drawings	3 00
"	12.	H. V. Bostwick, Baskets	3 73
"	12.	J. W. Kerr, Plants	3 90
"	12.	G. S. Joselyn, Trees and bushes	3 99
"	20.	H. A. Dreer, Seeds	24
"	20.	C. O. Voegelin, Labor	5 73
"	31.	J. Scutt, Hay	2 50
		Amount carried forward,	$ 559 33

1899		Amount brought forward	$ 559 33
Jan.	3.	U. S. Express Co., Expressage	50
"	4.	Andrus & Church, Blank books, tags, etc	2 56
"	5.	Ira Grover, Labor	37 50
"	28.	A. Lampkin, Oats	37 22
Feb.	1.	Ira Grover, Labor	37 50
"	2.	B. Chase, Pot labels	6 34
"	3.	Pritchard & Son, Repairs on wagon	9 45
"	6.	Andrus & Church, 500 postals. printing, etc	10 00
"	11.	F. Hoch, Willow cuttings	2 00
"	18.	G. W. Tailby, Hay and straw	28 52
"	18.	U. S. Express Co., Expressage	30
Mar.	4.	Ira Grover, Labor	37 50
Apr.	1.	Ira Grover, Labor	37 50
"	13.	American Florist Co., 1 directory	2 00
"	13.	J. M. Thorburn & Co., Seeds	3 26
"	13.	F. R. Pierson & Co., Flower bulbs	3 46
"	13.	Brown & Barnard, Sundry supplies	5 30
May	3.	Treman, King & Co., 1 lawn mower	10 00
"	3.	Ira Grover, Labor	37 50
"	5.	S. L. Sheldon, Photos	60
"	5.	White & Burdick, Sponges	94
"	11.	W. P. Simmons & Co., Geraniums	6 75
"	22.	Burns Bros., Horseshoeing	3 00
"	22.	J. M. Thorburn & Co., Seeds	83
"	22.	George Small, Lumber	13 48
"	24.	L. V. R. R. Co., Freight and cartage	1 83
"	26.	J. M. Thorburn & Co., Seeds	8 57
"	26.	Fall Creek Milling Co., Bran	1 89
June	3.	George Grover, Labor	28 00
"	3.	Ira Grover, Labor	37 50
"	7.	The Cottage Gardens, Seeds and plants	11 90
"	7.	Rochester Optical Co., Slides	3 32
"	7.	C. J. Rumsay & Co., Supplies for forcing-house	103 82
"	19.	D. B. Clark, Labor	2 85
"	27.	E. A. Ormsby, Ventilator apparatus	20 00
"	28.	Treman, King & Co., Sundries for forcing-houses	3 80
"	28.	Ira Grover, Labor	42 50
		Total for Horticultural Division	$1,159 32

FOR CHEMICAL DIVISION.

1898			
July	14.	C. U. Chemical Dept., Sundry supplies and chemicals	$ 68 84
Oct.	31.	L. V. R. R. Co., Freight and cartage	20
1899			
Jan.	4.	Bush & Dean, Linen	63
		Total for Chemical Division	$ 69 67

FOR BOTANICAL DIVISION.

1899			
July	2.	U S. Express Co., Expressage	$ 60
"	2.	The Bool Co., Repairs	4 00
"	13.	J. Carbutt, Photographic supplies	3 16
"	13.	Bausch & Lomb, Sundry supplies	20 91
		Amount carried forward,	$ 28 67

	Amount brought forward	$ 28 67
Aug. 11.	The Bool Co., Repairs	4 00
" 11.	Bausch & Lomb, Alcohol	6 83
" 19.	H. Hasselbring, Traveling expenses	26 15
" 25.	J. Carbutt, Photo. plates.	6 84
Oct. 5.	G. F. Atkinson, Traveling expenses	56 43
Nov. 10.	Bausch & Lomb, Optical Co., Sundry supplies	17 01
" 10.	White & Burdick, Drugs	10 44
Dec. 3.	U. S. Express Co., Expressage	1 00
" 7.	Bausch & Lomb, Vials, covers, etc	25 65
1899		
Jan. 4.	Mrs. W. A Murrill, Labor	22 20
" 4.	Bausch & Lomb, Shutters for lens	1 00
" 4.	E. MacGillivray, Photo. supplies	17 61
" 23.	Bausch & Lomb, Vials	9 56
Apr. 10.	Cambridge Supply Co., Publications	5 00
" 13.	Reed & Montgomery, Binding book	1 00
" 24.	G. E. Stechert, Publications	5 67
" 29.	U. S. Express Co., Expressage	1 15
May 15.	G. E. Stechert, Publications	36 35
" 26.	G. G. Allen, Foreign publications	20 24
June 7.	J. Carbutt, Photo. plates	4 84
" 7.	E. MacGillivray, Photo plates	4 68
" 8.	White & Burdick, Drugs	8 74
" 9.	G. F. Atkinson, Sundry supplies	18 25
	Total for Botanical Division	$ 339 31

FOR VETERINARY SCIENCE DIVISION.

1899		
May 31.	Cornell University Agr. Dept., Sundry supplies	$ 30 20

FOR ENTOMOLOGICAL DIVISION.

1898		
July 25.	Treman, King & Co., Sundries	4 19
" 25.	Andrus & Church, Stationery	1 04
Aug. 2.	F. K. Luke, Labor	8 55
" 8.	E. E. Slingerland, Labor	2 00
" 11.	Rothschild Bros., Sundry supplies	3 64
" 25.	Library Bureau, Car Index outfit	7 65
" 25.	D. B. Stewart, Kerosene	4 15
" 27.	F. K. Luke, Labor	10 00
" 29.	B. M. McCartney, Labor	7 50
" 29.	U. S. Express Co., Expressage	3 05
Sept. 12.	Library Bureau, Book	1 50
" 12.	J. W. Halsey, Cartage	25
Oct. 4.	The Bool Co., 1 chair	4 00
" 11.	Bausch & Lomb, 1 standard triplet	16 50
" 20.	H. A. Dreer, Seeds	2 36
" 21.	Bausch & Lomb, 2 filters, etc	8 80
Nov. 8.	L. V. R. R. Co., Freight and cartage	1 17
" 14.	Cornell University Dept. of Repairs, Labor	22 44
Dec. 1.	Bell Telephone Co., Repairs, etc	10 00
" 3.	Jameison & McKinney, Plumbing	9 70
" 3.	G. M. Galarneau, Labor	19 35
" 5.	Treman, King & Co., Paint and brush	1 37
1899		
Apr. 25.	D. B. Stewart & Co., Kerosene	4 76
	Total for Entomological Division	$ 153 97

SUMMARY.

The Agricultural Experiment Station of Cornell University,
In account with
The United States Appropriation.

1899	Dr.		
	To receipts from Treasurer of the United States as per appropriation for the year ending June 30, 1899, under Act of Congress approved March 2, 1887		$13,500.00
	Cr.		
June 30.	By Salaries	$8,568 34	
	Buildings	48 75	
	Office and Printing	2,618 48	
	EQUIPMENT, LABOR AND CURRENT EXPENSES.		
	Agriculture	511 96	
	Horticulture	1,159 32	
	Chemistry	69 67	
	Botany	339 31	
	Veterinary Science	30 20	
	Entomology	153 97	
			$13,500 00

RECEIPTS.

From Agricultural and Horticultural Divisions	$ 627 32

Appendix III.

Teachers' Leaflets on Nature Study.

No. 12. How the Trees Look in Winter.
No. 13. Evergreens, and How They Shed Their Leaves.

NATURE STUDY BULLETINS.

No. 1. Nature Study.

READING COURSE FOR FARMERS.

No. 1. The Soil ! What it is.
No. 2. Tillage and Under-drainage ! Reasons why.
No. 3. Fertility of the Soil ! What it is.
No. 4. How the Plant gets Its Food from the Soil.
No. 5. How the Plant gets Its Food from the Air.

No. 12.
JANUARY, 1899.

TEACHER'S LEAFLETS.

FOR USE IN THE PUBLIC SCHOOLS.

BY L. H. BAILEY
AND
C. W. FURLONG.

PREPARED BY

THE COLLEGE OF AGRICULTURE, CORNELL UNIVERSITY,

ITHACA, N. Y.

Issued under Chapter 67, of the Laws of 1898.

I. P. ROBERTS, DIRECTOR.

I. How the Trees Look in Winter.

L. H. BAILEY.

ONLY the growing and open season is thought to be attractive in the country. The winter is bare and cheerless. The trees are naked. The flowers are under the snow. The birds have flown. The only bright and cheery spot is the winter fireside. But even there the farmer has so much time that he does not know what to do with it. Only those who have little time, appreciate its value.

But the winter is not lifeless and charmless. It is only dormant. The external world fails to interest us because we have not been trained to see and know it; and also because

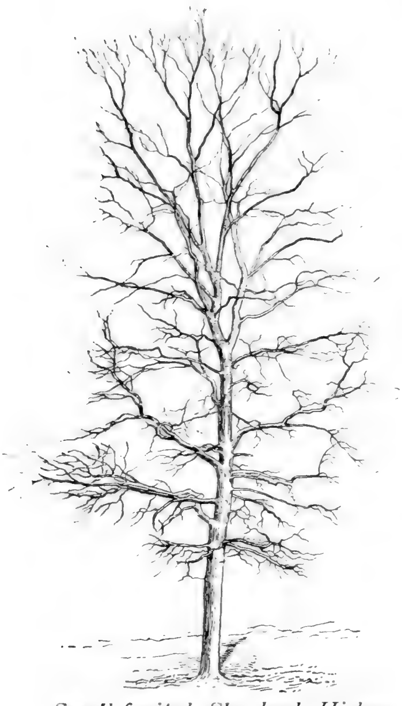
To the teacher.—We want the country child to have a closer touch with nature in the winter time. Teach him to see, to know, and to care for the trees when they are leafless. This leaflet will suggest how you may interest him.

You can also intensify his interest in the subject, and at the same time increase his knowledge of drawing, by having him make skeleton or outline drawings of the trees about the schoolhouse or the home. Part II. of this leaflet, written by one of the Instructors in drawing in the Cornell University, will aid you in this attempt.

You can correlate this work with geography by giving the distribution or range of the different kinds of trees. Indicate the limit of distribution northward, southward, eastward, westward; also the regions in which the species is most abundant. The common manuals of botany will help you in this work; or you may consult Apgar's "Trees of the Northern United States" (Amer. Book Co.), or Mathew's "Familiar Trees and their Leaves" (Appleton).

In teaching nature-study, remember that a great part of its value lies in the enthusiasm and zeal with which you handle it. Try, also, to develop the æsthetic sense of the pupil; but do not teach mere sentiment.

the rigorous weather and the snow prevent us from going afield. In the spring, summer, and fall, the hours are full to overflowing with life and interest. On every hand, we are in contact with nature. If the farmer's winter is to be more enjoyable, the farmer must have more points of contact with the winter world. One of the best and most direct of these points of sympathy is an interest in the winter aspects of trees. Let us consider the subject a moment.



25. *Small-fruited Shagbark Hickory.*

26. *Pignut Hickory. This and Fig. 25 are from "Lessons with Plants."*

a. The structure of the tree-top.

In the summer time, we distinguish the kinds of trees chiefly by means of the shape and the foliage. In winter the foliage is gone; but the shape remains, and the framework of the tree is also conspicuous. Trees are as distinct in winter as in summer; and in some respects their characters are more apparent and pronounced.

Observe the outline of a tree against the dull winter sky. It does not matter what kind of tree it is. Note its height, shape

and size of top, how many main branches there are, how the branches are arranged on the main trunk, the direction of the branches, whether the twigs are few or many, crooked or straight.

Having observed these points in any tree, compare one kind of tree with another and note how they differ in these features. Compare an apple tree with an elm, an elm with a maple, a basswood with a pine, a poplar with a beech, a pear tree with a peach tree.

27. *Slippery Elm. The expression is stiff and hard.*

Having made comparisons between very dissimilar trees, compare those which are much alike, as the different kinds of maples, of elms, of oaks, of poplars. As one's powers of observation become trained, compare the different varieties of the same kind of fruit trees, if there are good orchards in the vicinity. The different varieties of pears

afford excellent contrasts. Contrast the Bartlett with the Flemish Beauty, the Kieffer with the Seckel. In apples, compare the Baldwin with the Spy, the King with the Twenty Ounce. The sweet and sour cherries show marked differences in method of branching. Fruit men can tell many varieties apart in winter: how?

28. *Swamp White Oak.*

Two common hickories are shown in Figs. 25 and 26. How do they differ? Do they differ in length of trunk? General method of branching? Direction of branches? Character of twig growth? Straightness or crookedness of branches?

Contrast the slippery elm (Fig. 27) and the common or American elm (Fig. 34). The former has a crotchy or forked growth, and long, stiff wide-spreading branches. The latter is more vase-like in shape. The branches are willowy and graceful, with a tendency to weep.

Compare the oaks. The white and scarlet oaks have short trunks when they grow in fields, and the main branches are comparatively few and make bold angles and curves. The swamp white oak (Fig. 28), however, has a more continuous trunk, with many comparatively small, horizontal and tortuous branches.

With Fig. 28 compare the pepperidge (Fig. 29). This is one

of the most unusual and interesting of all our native trees. It grows in swales. It has a very tough-grained wood. The autumn foliage is deep red and handsome. The peculiarties of the tree are the continuation of the trunk to near the summit, and the many lateral short deflected tortuous branches.

Consider the structure of the sassafras in Fig. 30. The great branches stand off nearly at right angles to the trunk, and are bushy and twiggy at the ends. Each large branch if cut off at its base and stood upright would look like an independent tree, so tree-like is its branching. Observe how much more bushy the sassafras is than any of the other trees already figured. Compare the method of branching and the twiginess with the slippery elm (Fig. 27).

But there is still greater brushiness in the thorn-apple (Fig. 31). The twiginess in Figs. 30 and 31 is very unlike, however. Pick out the differences. Observe the very short and spur-like twigs in the thorn-apple; also notice how soon the trunk is lost in the branches.

29. *Pepperidge or Sour Gum. The oddest of New York trees.*

With all the foregoing pictures compare the steeple-like form of the Lombardy poplar (Fig. 32). The tree is frequent along roadsides and about yards. What is its structure? Observe it as it stands against the winter sky. There is nothing else in our northern landscape so straight and spire-like. If you know a beech tree standing in a field, contrast it with the Lombardy poplar. These two trees represent extremes of vertical and horizontal branching.

Aside from the general structure of the tree-top, the pupil will become interested in the winter color of the tree and in the character of the bark. How does the bark differ between elms

and maples, oaks and chestnuts, birches and beeches, hickories and walnuts? Why does the bark separate in ridges or peel off in strips? Is it not associated with the increase in diameter of the trunk? The method of breaking of the bark is different and peculiar for each kind of tree.

30. *Sassafras. Type of a bushy-topped tree.*

Look at these things; and think about them.

b. The expression of the tree.

Consciously or unconsciously, we think of trees much as we think of persons. They suggest thoughts and feelings which are also attributes of people. A tree is weeping, gay, restful, spirited, quiet, sombre. That is, trees have expression. The expression resides in the observer, however, not in the tree. Therefore, the more the person is trained to observe and to reflect, the more sensitive his mind to the things about him, and the more meaning the trees have. No one loves nature who

does not love trees. We love them for what they are, wholly aside from their uses in fruit-bearing or shade-giving. A

31.—*Thorn-apple. One of the most picturesque objects in the winter landscape.*

knowledge and love of trees binds one close to the external world.

How shall one increase his love of trees? First, by knowing them. He learns their attributes and names. Knowing them in winter, as already suggested, is one of the ways of becoming acquainted. Second, by endeavoring to determine what thought

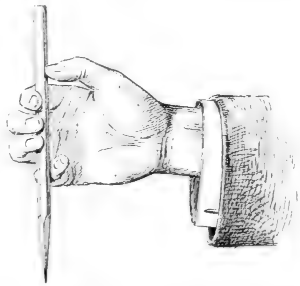
or feeling they chiefly express. The slippery elm is stiff and hard. The American elm is soft and graceful The Lombardy poplar is prim and precise. The oak is rugged, stern and bold. The pepperidge is dejected. The long white branches of a leaning buttonwood standing against a distant forest, suggest some spectre hurrying away from the haunts of men.

32. *Group of Lombardy Poplars. From Bulletin 68.*

Trees which have very strong expressions, or which are much unlike others, are said to have character. They are peculiar. Of such trees are oaks, pepperidge, Lombardy poplar, buttonwood, old apple trees.

A tree with very strong characters is said to be picturesque. That is, it is such an object as an artist delights to put into a picture. Trees which are very unsymmetrical, or knotty, gnarled or crooked, are usually picturesque. Of all common trees, none is more picturesque than an old apple tree. Observe its gnarled and crooked branches, and the irregular spaces in its top.

Encourage the pupil to extend his observation to all the trees about him, especially to such as are common and familiar. Teach him to observe the growths of bushes and trees in the fence-rows which lie on his way to school; and to observe carefully and critically. How do gooseberry bushes differ from currant bushes, and raspberries from blackberries? Observe the lilac bush and the snowballs. How is the snow held on the different kinds of evergreens, —as the pines, spruces, arbor-vitæ? See how the fruit-spurs on pears and plums stand out against the sky. (Consult Leaflet No. 3, "Four Apple Twigs.") Are there any bright colors of branch and twig to relieve the bareness of the snow? Do you see any warmth of color in the swales where the willows and osiers are? Do you see old plumes of grass and weeds standing above the snow? Do they bring up any visions of summer and brooks and woods?



33. *How to test the drawings.* *See p. 142.*

II. One Way of Drawing Trees in Their Winter Aspects.

CHARLES W. FURLONG.

The few suggestions which are set forth on these pages are based upon two assumptions:—first, that the teacher has some knowledge of the most salient principles of elementary perspective; and second, a love for all things beautiful. It is not feasible to deal here to any extent with art in either its abstract or concrete form, but only with drawing.

Drawing, in its simplest analysis, is the ability to record objects as they appear to the normal eye. There are no outlines in nature.

Art is more complicated. It includes many elements, a few of which are composition, expression of movement, and action. The very thought, feeling and refinement of the artist must be expressed in his work. He must tell not only what he sees, but also what he feels.

The boundaries, shapes and character of various forms are determined by the difference of their color values, and the contrasts of light and shade. Yet an outline drawing is the simplest means of representing form and proportion. Although inadequate in many respects, this somewhat conventional rendering is all-important to the beginner, for it is absolutely necessary that the child be taught to observe forms and proportions correctly; and these impressions may be recorded most simply and definitely by outline drawings. Michael Angelo emphasized its importance in these words: "The science of drawing or of outline is the essence of painting and all the fine arts, and the root of all the sciences."

To a great extent, one may show in an outline drawing the character and texture of surfaces. Our main object should be to train the boys and girls to observe in order to acquire a correctness of preception, for "education amongst us consists too much in telling, not enough in training."

One of the greatest difficulties is to impress upon the minds of beginners the fact that they must think while they look and draw Insist upon the pupil looking repeatedly at the object.

34. *The American elm, one of the most typical of vase-form trees.*

It is better to observe for five minutes and draw for one, than to observe for one and draw for five.

We may make our drawing lesson more interesting by telling the class something about the object which they are to draw, involving in our story facts that will tend to impress upon their minds some of the most salient characteristics of the object. We should encourage the children to discuss the object, drawing out facts from their own observation. Certain kinds of trees, like certain races of people, have a general similarity, yet every single tree has an individuality of its own.

Let us apply a few essential questions that will help us to determine at least the kind of tree it is, the race to which it belongs; for first we must get its general character, seeing its big proportions and shape; and later must search for its individualities.

Is it tall for its greatest width?

How far does the trunk extend before dividing?

At what height do the lowest branches begin?

What is their general direction?

Do they appear to radiate from the trunk?

How do the main branches compare in size with the trunk?

Are they crooked or straight?

The manner of branch growth must be studied carefully.

We see in our elm (Fig. 34) that the trunk divides at about a fourth of its height into several main branches, while in the cases of the pepperidge (Fig. 29) the trunk extends to the very top of the tree, the branches being small in proportion to the trunk, not varying much in size, and taking an oblique downward direction. Notice the weird expression of these trees with their crookedly bent tops, one side of each trunk being almost devoid of branches.

The trunk of the sassafras (Fig. 30) continues nearly to the top of this tree, while the large branches, though unsymmetrical, give it a well balanced appearance.

Again in our picture of the thorn-apple (Fig. 31), we are at once impressed with its irregular form, the branches on the left taking a more oblique direction than those of the other side, the trunk dividing a little short of half the height of the tree.

35. *Blocking-in the elm tree (Fig. 34). The first work which the artist does when he draws the tree.*

We may now take up our lesson. Our subject is an elm tree (Fig. 34); our medium, lead pencil; our drawing to be rendered in outline.

Material.—Almost any good drawing paper, white or buff in color, will answer our purpose: 9x12 is a good size. Our pencil should be of medium grade lead (F. or HB.) of any standard make, Kohinoor preferred.

If procurable, we should have a light drawing board 17x22 inches (here is an opportunity for the carpenters) to place the paper on, otherwise a very stiff piece of cardboard; or a large geography book might answer. It is best, however, to fasten our paper, which we cannot do in using the book. For fastening the paper we shall need four thumb tacks for the corners.

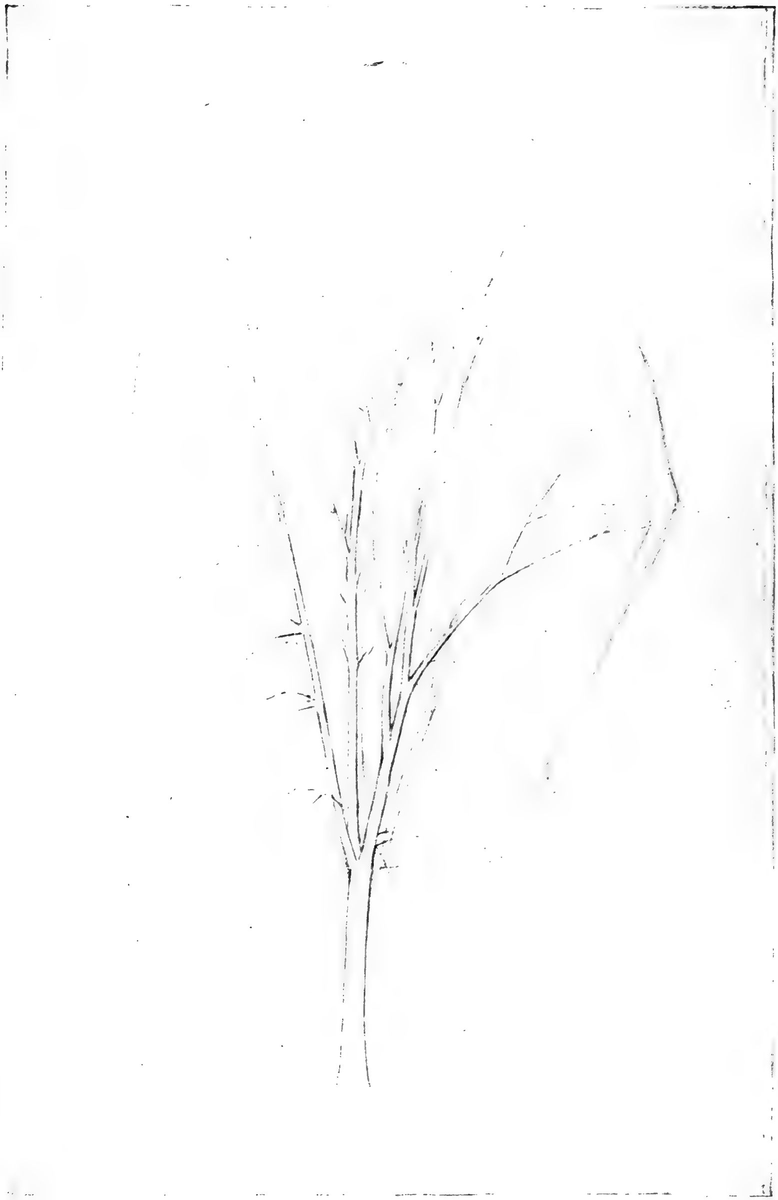
A Faber or multipex pencil eraser is needed; also a sponge eraser with which to remove the light lines and clean the drawing before lining it in.

Our position.—Our point of view will depend upon our subject, but it is not well to be so near as to necessitate raising the head in order to see the top of the tree. If we take longer than one sitting for our drawing (which I do not think advisable, as we must not choose too complicated a subject) we must mark our position in order to again obtain the same point of view.

Position of the drawing-board.—Our paper must be placed on the board with its edges parallel to those of the board. The drawing-board should be held perpendicular, or nearly so, to the direction in which it is seen, for if the board is tilted far backward, it will be fore-shortened and our tree probably will have been drawn longer than it should be.

How to look.—The tendency of the beginner is to see and draw too much in detail. It is most essential that we look first for the large shapes, the greatest dimensions; next for the smaller ones; last for detail. It is not well for the pupils to work too close to their drawings. They should occasionally sit well back in their seats or get up and stand behind their chairs in order to obtain the general effect of their drawing, to see that the big shapes are right and that the spirit of the tree has not been lost.

As an aid to placing our drawing so as to best fill the space it has to occupy, we may use what the French call a "*cherche-motif,*" the English, a finder. This is nothing more than a small



36. *Working in the details with sharp lines. The original pencil sketch is not followed exactly.*

piece of stiff paper or cardboard, about 5x8 inches, in which is cut a small rectangular opening ¾x1 inch; the size may vary somewhat. We may look through this opening, the card acting as a frame to our picture. This will help us to decide whether our subject will look better placed the horizontal or vertical way of the paper. We may include more or less in the finder by varying its distance from the eye.

Now, I am sure we would not place ourselves within a dozen yards of our tree if we wished to get its general effect; therefore, we must have plenty of foreground in our drawing. We must give the eye a chance to look, allowing plenty of space between the lowest point of our drawing and the lower edge of our paper. We must also avoid crowding it to the right or left.

As the height of tree we are to draw (Fig. 34) is greater than its greatest width, we find that it will fill the space best if placed the vertical way of the paper. After indicating the extreme height and width by four light marks, before carrying the drawing further we must test these proportions by comparing the width with the height, always testing the shorter dimension into the longer, viz.:

To test the drawing.—Close one eye. The pencil may be used to test the drawing by holding it in front of one at arm's length (as in Fig. 33) perpendicular to the direction in which the object is seen; also revolving it in a plane perpendicular to the direction in which the object is seen, in order to compare one dimension with another. For example, hold your pencil horizontally at arm's length so that its blunt end covers the outermost left-hand point of the elm. Slide your thumb along the pencil till it covers the extreme right-hand point; retain that measurement (keeping the same position in your chair, pencil always at arm's length); revolve the pencil in the same plane until it coincides with the height of the elm, at the same time lowering it so that the end of the thumb covers the lowest point of the tree; note carefully the point that the blunt end covers; raise the pencil so that the end of the thumb covers that point, noting again where the blunt end occurs and notice how many times, and over, the width goes into the height. In our elm (Fig. 34) we find that the width goes about once and six-sevenths, into the height, or a little

37. *The outline drawing complete, and the first pencil marks erased.*

short of twice. If the latter statement is preferred, we must bear in mind the proportion left over.

Do not use the scale side of a ruler or marks on the pencil or object used in order to test the proportions. A scale or other mechanical means should not be used in free-hand drawing. The teacher should have a spool of black thread and should give a piece about 2 ft. 6 inches long to each pupil. An eraser, a knife, or some small article may be attached to one end of the thread. By holding the weighted thread as a plumb-line in front of us, we have an absolutely vertical line; so by having it intersect a desired point of our tree we may obtain the relative positions of other points to the right and left of this intersected point.

Blocking-in.—We may conceive of the general shape of our elm by looking at it with half-closed eyes. It appears in silhoutte. Now imagine lines joining its outermost points; this will give the general mass or shape of our tree. Now if we represent these outermost points contained in these lines, by sketching lightly these "blocking-in" lines, as they are called, we obtain the general shape of the elm (Fig. 35). We must emphasize the fact that these blocking-in lines be sketched in lightly by holding the pencil near the blunt end, using a free-arm motion. Now before going farther we again test these new points to see if they occupy their right positions in relation to the height and width. Do not, however, transfer the measurements from the pencil to the paper. This test is only to obtain the proportion of one dimension to another. Having tested these smaller dimensions we may draw lightly the main branches.

After having indicated their general direction and character of growth, we may indicate some of the smaller branches and twigs (Fig. 36). All this work should be carried out without erasing; all corrections should be made by slightly darker lines.

Let us now sharpen our pencils to a good point and go over the drawing with a fine dark line, carefully studying the character and spirit of the tree. Now erase the lighter and superfluous lines, as the dark lines remain distinct enough to indicate our drawing.

Lining-in.—We may now take our pencil nearer the point and

proceed to line-in the drawing, going over it with a definite consistent line. If desirable, we may accent and bring out certain parts of the tree stronger than others by darker or shade lines and short strong markings called accents. These are especially effective at the junction and underside of branches, and where one wishes to give the object a nearer appearance. We should be cautious in using them, however; but lack of space does not permit further discussion of the subject of accented outlines.

We should also allow the pupils to make short ten or fifteen minute "time sketches" of trees. In these, it is the spirit and general effect of the tree that we must strive for. Above all, we must allow our little draughtsman to give his own interpretation of the tree. A helpful suggestion as to proportion, etc., would be in place, but we must allow his individuality to have as much play as possible.

The suggestions given on these pages are necessary for the beginner. Some of them are hard facts; but it lies with the teacher to develop the æsthetic and artistic qualities lying dormant in the pupil, ready to be moulded and started in the right direction.

If you have confined the pupils to the flat copy, break away from it; allow them to create. Let them see the beautiful things all about them. They will respond. Let them draw from nature and still life. Train them to observe.

The early summer days, just before school closes, with their bright sunlight and strong shadows, make many subjects interesting as light-and-shade drawings. Fall with its brilliant coloring gives us a chance to use the color-box, while the early winter twilights will bring many an interesting silhouette before our boys and girls, which next day during the drawing hour may be carried out in pen and ink.

The most successful teacher will be the one of sympathetic nature whose love reaches out to the boys and girls, as well as to all things beautiful. The most successful teacher will be the one who endeavors to place the children where they may view nature sympathetically and with the most intimate relationship.

These leaflets are designed to suggest means and methods by which teachers may interest children in nature-study. The ultimate object of our work is to inculcate a love for country life, and this can best be done by interesting the coming generation in country things. The teacher will also find nature-study to be directly valuable as a means of education, or training the mind of the child. We want your full co-operation and your unreserved criticism. Any communication which you may send to us will receive prompt and direct attention :

The following leaflets have been issued to aid teachers in the public schools in presenting nature-study subjects to the scholars at odd times :

1. *How a squash plant gets out of the seed.*
2. *How a candle burns.*
3. *Four apple twigs.*
4. *A children's garden. For the pupils.*
5. *Some tent-makers.*
6. *What is nature-study?*
7. *Hints on making collections of insects.*
8. *The leaves and acorns of our common oaks.*
9. *The life-history of the toad.*
10. *The birds and I.*
11. *Life in an aquarium.*
12. *How the trees look in winter.*

Bulletin 159 gives a general review of the Cornell Agricultural Extension Work.

These will be sent free to all engaged in teaching in the public schools of the State of New York.

Address,

Bureau of Nature-Study,

College of Agriculture,

Ithaca, N. Y.

TEACHER'S LEAFLETS

FOR USE IN THE PUBLIC SCHOOLS

PREPARED BY

NO. 13.

FEBRUARY, 1899.

THE COLLEGE OF AGRICULTURE,
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I. P. ROBERTS, DIRECTOR.

Evergreens, and How They Shed Their Leaves.

BY H. P. GOULD.

CONE-BEARING evergreens are familiar to everyone; yet this familiarity is usually with the trees as entire objects. We do not often stop to analyze a tree in order to find out what gives it its characteristic appearance or to see what makes it look as it does.

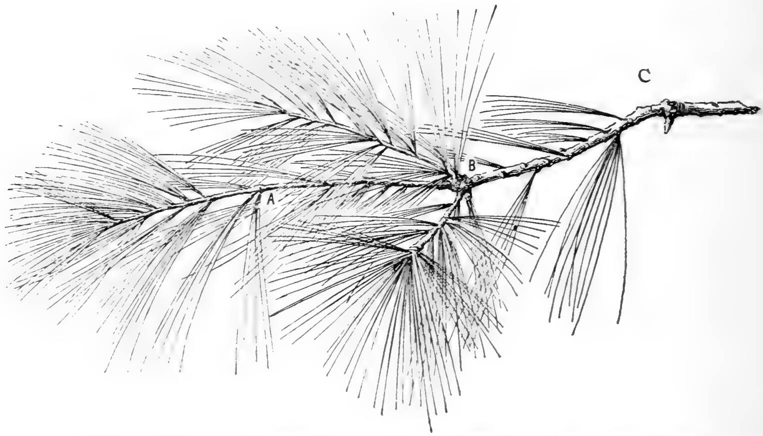
We will often find, if we stop to look, that much of the character of a tree,—that is, its general appearance or the way in which it impresses us,—is due to the leaves and to their arrangement on the branches. This is true of many of the evergreen trees.

Note to the teacher.—This leaflet has two particular objects: to teach how evergreens shed their leaves, and to enable you to distinguish a few of the evergreens which are most commonly met. These studies (and those suggested in Leaflet No. 12) should be the means of adding much cheer to the winter. Encourage pupils to make collections of cones, to observe when they shed their seeds, and how long (how many seasons) they remain attached to the branch. Remember that mere identification of the kinds of trees is not the highest type of nature-study.

Cones are good subjects for free-hand drawing. Beginners should draw them in outline, omitting the shading. Encourage pupils to draw single leaf-clusters of the different pines, cautioning them to get the right number of leaves in each case.

Why are certain kinds of trees called evergreen, in distinction from those which are said to be deciduous? The reason is obvious. One kind is always green from the presence of foliage, while the other sheds all of its leaves every season. The evergreen trees, like the pines and the spruces and firs, always appear to be well covered with foliage, so it does not often occur to us that these trees shed their leaves. And yet perhaps we can recall happy hours when we used to play beneath some large pine tree where the ground was carpeted with pine "needles."

The falling of the leaves of the maple trees or the oaks is a



38. *Shoot of the common white pine, one-third natural size.*

familiar sight, but who has seen the spruce leaves fall, and who can tell when the pine needles drop?

That the evergreen trees do shed their foliage, as truly as the maples and the elms do, we will not question, for we can see the fallen leaves under any tree. Look up into the top of a spruce or pine. See that the interior is bare of foliage. The leaves are towards the ends of the branches, where they receive sunlight. Yet the branches which are now on the interior once bore leaves, for we can see the leaf-scars.

It will be interesting to find out something about the leaves of our common evergreens. Let us look at some of them.

THE WHITE PINE.

In Fig. 38 is shown a white pine branch. Notice that the leaves are borne in bunches or clusters of five. Each bunch of leaves is produced in the axil (or angle) of a minute scale-like body, but this scale cannot usually be found except on the very young growth. It has been worn away or broken from the older growth by the wind and the rain and the other forces of nature.

39. *Cone of white pine. It has shed its seeds. Half natural size.*

Another strange fact should attract our attention. The leaves of the maples and other deciduous trees are borne only on the present season's growth; but this is not the case in the pines, and kindred trees. If we trace back the growth of the past two or three years, we shall find that there are as many leaves on the wood that is two years old as there are on the last season's growth; and in many cases we can find leaves on the part of the branch that is three years old. This means that the pine leaves or needles are two and sometimes three years old when they fall. The Fig. 38 shows the falling of the leaves from the different years' growth. The part of the branch between the tip and A is the last season's growth; between A and B it is two years old; the part between B and C is three years old. The part that grew four seasons ago—beyond C— has no leaves.

The different season's growth is not indicated by distinct "rings" as in the case of deciduous trees (See Leaflet No. 3), but by the branching. Each whorl of branches about a limb represents the end of a season's growth. A young pine tree, or the younger limbs of an old tree, show this character very plainly.

Do the leaves of the pines and of the other evergreen trees fall at the end of the growing season, as the leaves of most of the deciduous trees do? Or do they gradually become lifeless and fall at any season, from the force of the wind and other forces of

nature? Tie a large sheet of cloth in the top of some evergreen tree, in such a way as to form a receptacle to catch the leaves. Do you catch leaves in winter as well as in summer?

There are several different kinds of pines, so we must picture carefully in our minds the foliage of the white pine, for it is different from that of any others. The leaves are soft and very slender, and from three to four inches long. The base of each cluster of leaves is at first surrounded by a small sheath-like

40. *Shoot of common pitch pine. One-half natural size.*

body, but this falls away when the leaves are still very young. A scar is left when the leaves drop and these scars can often be seen on parts of the branches that are eight or ten years old. Do the leaves of other kinds of trees make a scar when they fall?

The white pine cones, in which the seeds are borne, are conspicuous objects. They are five or six inches long and slightly curved. It will be interesting to find out if the seeds ripen the same year in which they are formed. Perhaps a cone still containing seeds can be obtained. Carefully tear it apart and see where the seeds are attached. Red squirrels sometimes eat the pine seeds. A white pine cone, which has shed its seeds, is shown in Fig. 39.

This kind of pine is found widely scattered in New England, New York and westward to Minnesota and Iowa and along the Allegheny Mountains as far south as Georgia ; also in some parts of Canada. It is a valuable lumber tree.

THE PITCH PINE.

This kind of pine is very different, in many respects, from the white pine. Let us find some of the differences. Instead of having leaves in bunches of five, it has them in clusters of three, and the base of each cluster is inclosed by a scaly sheath which does not fall away as in case of the white pine ; neither does the little scale-like body upon the branch, in the axil of which the leaf-cluster is borne, fall away, but it may be found just below the leaf, and even on branches that are several years old. Sometimes a sheath is found with only two leaves. We shall want to know, too, how old the leaves are when they fall. Do they remain on the tree longer than the white pine leaves do?

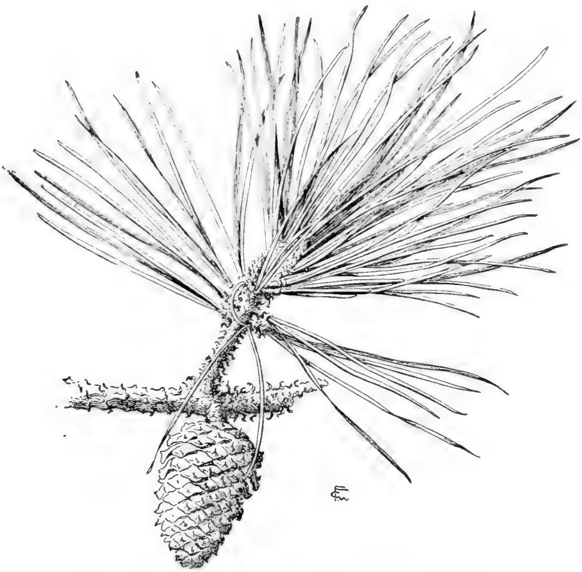
41. *Cone of pitch pine. One-half natural size.*

Again, instead of being soft and slender as the white pine leaves are, we shall find that these leaves are rigid and large in comparison, and stand out straight from the branches. The shape of the leaves is also distinct from the white pine needles. See if you can find any other differences.

A pitch pine branch is shown in Fig. 40. The part between the tip and A is the past season's growth. Observe the foliage on the part that is two years old. Part of it has fallen. We often find it on growth which is older than this ; but in this specimen there are no leaves on the three-year wood.

The cone of the pitch pine is very unlike that of the white pine. Fig. 41 gives a good idea of one which has shed its seeds. Compare this with Fig. 39 ; or, better, examine the two kinds of cones side by side. The pitch pine cones are sometimes borne in clusters of two or more and they persist,—that is, remain on the tree for several years after the seeds have ripened and scattered.

Notice how the new cones are borne with reference to last season's growth. Are they attached to the tip of a branchlet? Or are they closely attached to the side of a branch? Figs. 42 and 43 will help us answer this question. The little cones in Fig. 43, near the tip of the twig, are just beginning to form.



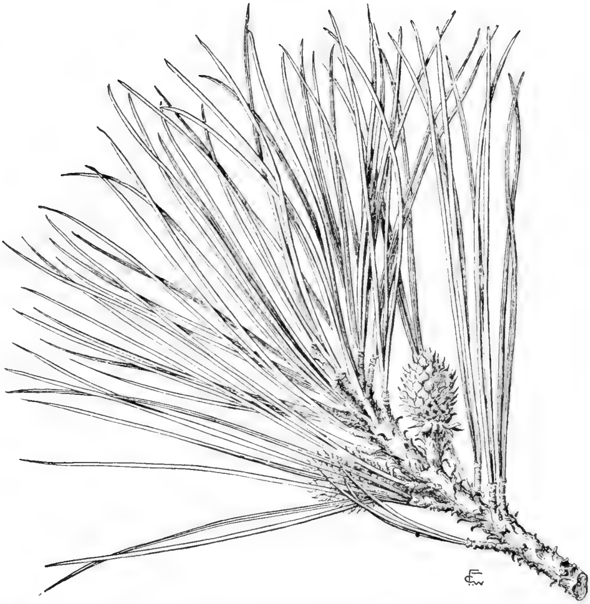
42. *Pitch pine. One-third natural size.*

The pitch pine usually grows in sandy or rocky soil and is found in the United States along the Atlantic coast to Virginia, along the mountains to Georgia, westward to Western New York, Eastern Ohio, Kentucky and Eastern Tennessee. It has little value as timber, because it does not grow large enough.

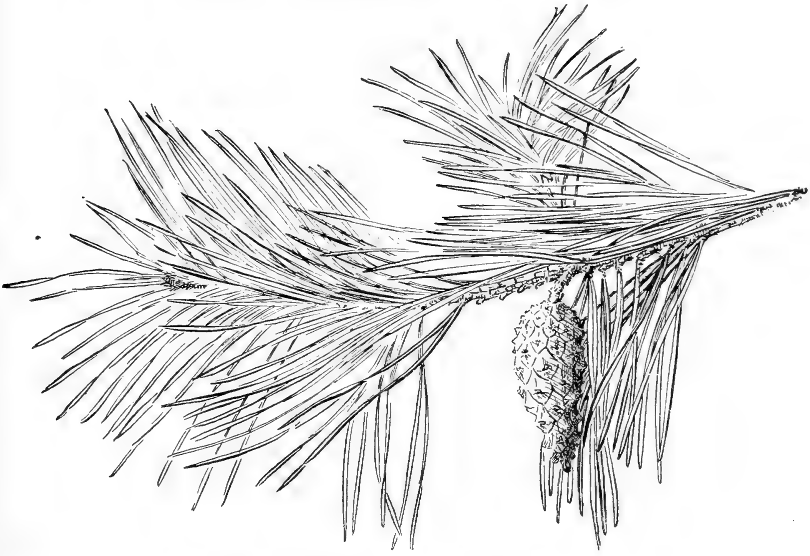
Scotch and Austrian pines.

In the same manner, other pines may be studied. Fig. 44 shows a cone and bit of foliage of the Scotch pine, and Fig. 45 the Austrian pine. These cones grew the past season and are not yet mature. After they ripen and shed the seeds which they contain, they will look something like the cone in Fig. 41. The Scotch pine has short and blue-green needles. The Austrian pine is coarser, and has long dark-green needles.

There are but two leaves in a cluster on these kinds of pines and we shall find that the sheath which incloses the base of the leaf-cluster is more conspicuous than in either the white or pitch pines. Do the leaves persist in the Scotch and Austrian pines



43. *Pitch pine, showing young cones. Half natural size.*



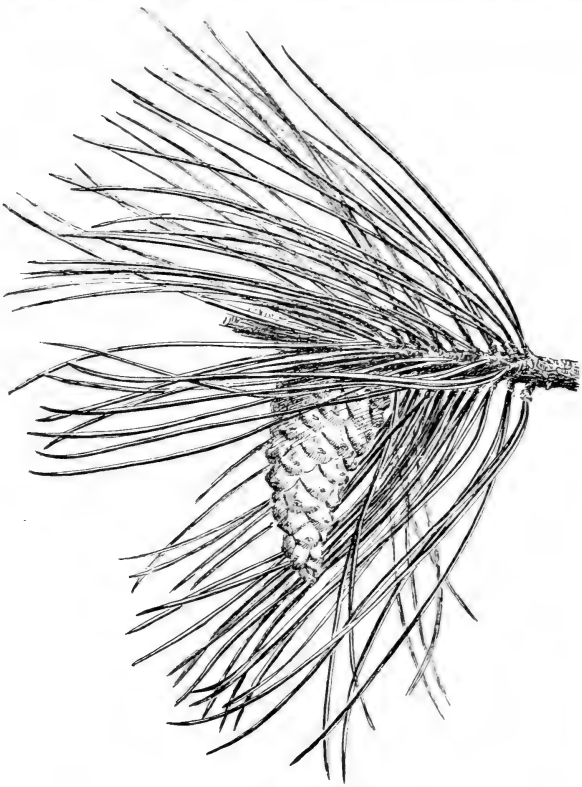
44. *Scotch pine. Half natural size.*

longer than they do in the others we have examined? Study the cones of these and other pines.

The Scotch and Austrian pines are not native to this country, but are much grown for ornament. They can be found in almost any park, and in many other places where ornamental trees are grown.

THE NORWAY SPRUCE.

The leaves of spruce trees are borne very differently from those of the pines. Instead of being in clusters of two or more, they are single and without a sheath at the base; neither are there scale-like bodies on the branches where the leaves are borne. Notice, too, that the leaves have a very short stem or petiole.



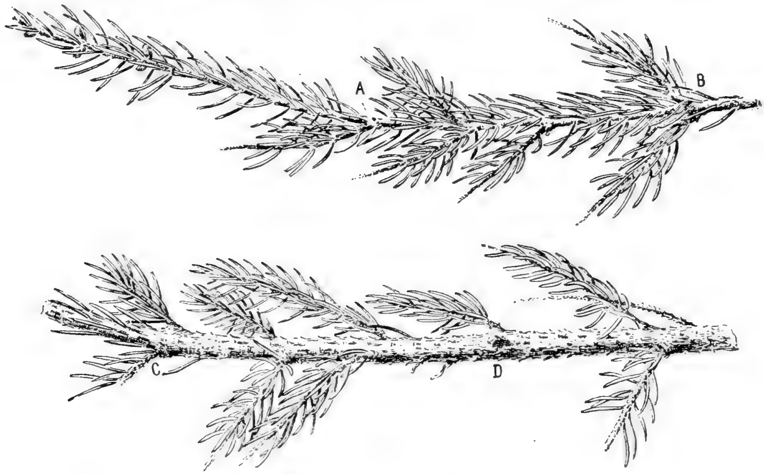
45. *Austrian pine. One-third natural size.*

The leaves of the Norway spruce are about one inch long, although the length varies more or less in different parts of the tree and in different trees. They are rather stiff and rigid and sharp-pointed. In a general way, the leaves are four-sided, though indistinctly so.

It will be interesting to study the position which the leaves

take on the branches. A hasty glance might give us the impression that the leaves are not produced on the under side of the branches; but a more careful examination will convince us that there are nearly as many on the under side as on the upper. The leaves are all pointing outward from the branch and as nearly upward as is possible. In other words, the leaves grow toward the light.

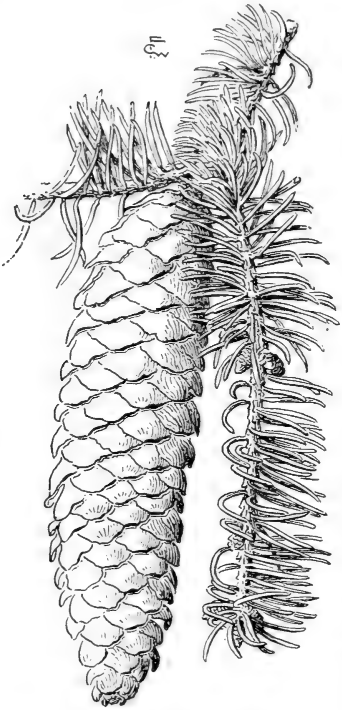
We must not forget to see how long the leaves of the Norway spruce persist and to find out when the leaf-scars disappear. We can find leaves that must surely be six or seven years old



46. *Twig of the common Norway spruce. Half natural size.*

and sometimes we can find them even older than this. The leaf-scars, too, remain a long time. The falling of the leaves is illustrated in Fig. 46. It shows the extremities of a limb which is eight years old. The part between the tip and A is last season's growth; between A and B it is two years old; and beyond B is a part that grew three seasons ago. The section beyond C is six years old; from C to D is seven years of age. The four years' growth of this limb not shown in the drawing was as densely covered with foliage as is the part shown in the upper figure; but there are not many leaves between C and D (seven years old) and none on the eight-year-old wood (except those on the branchlets, and these are younger.)

The cone of the Norway spruce is nearly as long as that of the white pine, but it is not so rough and coarse as the white pine cone is. The cones are usually borne on the tips of small branchlets, although occasionally one is found borne in the manner shown in Fig. 47. The cones usually fall the first winter.



47. *Cone of Norway spruce. Half size.*

The Norway spruce is not a native of this country, but, like the Scotch and Austrian pines, it was introduced from Europe and is grown very widely as an ornamental tree. It is the commonest evergreen in yards and parks.

The black spruce and its kin.

There are several different kinds of spruces which we find growing in our forests and swamps, and sometimes these are planted for ornament.

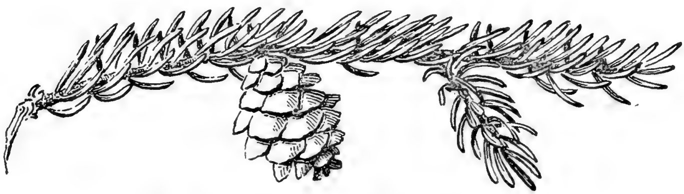
A sprig of foliage and a cone of one of these,—the black spruce,—is shown in Fig. 48. The foliage is not very unlike that of the Norway spruce, but the cones are very small in comparison. They are about one inch long, though they vary considerably in size. Before they open they are oval or plum-shape, but when mature and the scales of the cone have expanded, they are nearly globular. They are often borne in clusters, as well as singly, and persist for many years after the seeds have fallen. The position of the cones will depend upon their age. When young, they point upward, but they gradually turn downward.

The white spruce resembles the black very closely in general appearance. The leaves of the white spruce have a whitish or dusty looking tinge of color and when crushed or bruised, give forth a peculiar disagreeable odor. The cones vary in length from an inch to two inches, and in shape are more cylindrical or finger-shaped than the cone of the black spruce.

The foliage of the red spruce lacks the whitish tinge of color of the white spruce and the cones, which are from one inch to two inches in length, are obovate in shape — that is, the widest place is through the upper part of the cone, and from this point it gradually tapers to the tip. They seldom persist longer than the second summer.

The leaves of all these different kinds of spruces vary greatly in length, thickness and sharpness of point, according to the part of the tree on which they grow, and their surroundings. The shedding of the leaves on these or other spruces can be determined as easily as in the Norway spruce.

These three spruces like a cold climate and grow in many sections of northern United States and Canada and farther



48. *Black spruce. Half natural size.*

south in the mountains. They are sometimes all found growing together, but the black spruce likes best the damp, cold swamps, while the others grow best on the drier and better drained lands. The black spruce is commonest. The red spruce is least known.

THE BALSAM FIR.

This is another evergreen tree which grows naturally in the cold, damp grounds of the northern United States and Canada, and to some extent in the eastern states as far south as West Virginia.

The foliage is borne in much the same manner as that of the spruces ; yet there are interesting differences in the characters of these two kinds of leaves. Perhaps the most noticeable difference is in the shape ; and the color of the fir leaves will attract our attention because the under side is a silvery color, while the upper side is green. What is the nature of the tip of the leaf? and how does

it compare with the pines and spruces in this respect? Does the leaf have a stem or petiole? or is it attached directly to the branches without any stem? How are the leaves shed?

The cones are about three inches long and present a rather delicate appearance. It will be interesting to determine the position of the cones, that is, the direction in which they point, and to learn if it is the same when they are young that it is after they have matured.

The grayish colored bark of the trunk and limbs bears many "blisters" from which Canada balsam is obtained.

The hemlock.

A hemlock twig is an interesting object. It may have many characters in common with the spruce and fir, yet the impression which we get from it, or from a large hemlock tree, is entirely distinct. The arrangement of the leaves and the gracefulness of the drooping branchlets are most pleasing. We are lead to examine it more closely. We notice that the leaves appear to be borne in two more or less regular rows,—one on each side of the branch or twig; but in reality they come from all sides of the branch, and it is the position which the leaves assume that gives this two-rowed appearance.

The leaves have a short petiole or stem, and this stem rests along the side of the branchlet in such a direction that the leaves are placed in single rows on either side of the branch. The petioles of the leaves are nearly parallel with the branch while the leaves often make a decided angle with the petiole. This fact can best be brought out by carefully examining a small twig.

While we are noting the arrangement of the leaves on the branchlets, we should also take notice of the points of similarity and difference between these leaves and the spruces and firs. We shall find that there is more in common, at least so far as shape and color are concerned, between the hemlock and fir than between the hemlock and spruce.

The small delicate cones, borne on the tips of the branchlets, will also attract our attention (Fig. 49.) We may wonder at their small size, for they are only about three-quarters of an inch long, and very delicate, yet a second glance at the tree will impress us with

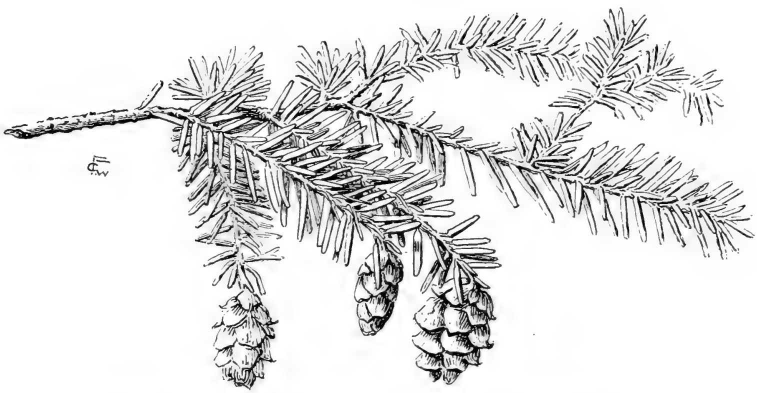
the number of cones which the tree bears: and we conclude that, although the cones may be small, yet there are so many of them that there will be no lack of seeds.

It is more difficult to trace the age of a hemlock limb than of many other kinds of trees, yet we can easily determine that many of the leaves are several years old when they fall.

The bark of the hemlock is used in tanning leather. The tree is much used for lumber. Where does it grow?

THE ARBOR-VITÆ.

One might almost wonder, at first sight, if the arbor-vitæ (often, but wrongly, called white cedar) has any leaves at all.



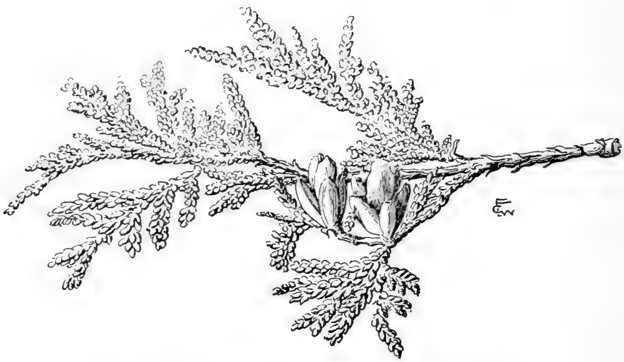
49. *Spray of the hemlock. Two-thirds natural size.*

It does possess them, however, but they are very different in size and shape from any of the others which we have examined. They are small scale-like bodies, closely pressed together along the sides of the branchlets, in four rows. Leaves pressed to the branches in this manner are said to be "appressed." The leaves of the arbor-vitæ are so close together that they overlap one another. The leaves are of two distinct shapes, sometimes known as the surface leaves and the flank leaves. The former are located on what appears to be the flattened surface of the branchlets, while the latter are on the sides or edges. See Fig. 50.

If we carefully look at the leaves, we shall notice a raised spot

near the point or tip. This is said to be a resin gland. This gland can be seen more plainly on the surface leaves that are two years old.

Most of the leaves persist for at least two and sometimes three years; but even older ones can be found. These older leaves, however, do not exist as green active leaves, but merely as dried up and lifeless scales. These lifeless leaves, are probably detached from the branches by the forces of nature.



50. *The Arbor-vitae. Nearly full size.*

The cones are even smaller than the hemlock cones. They are borne in the axils of the leaves in the same manner as the branchlets and are not conspicuous unless one is close to the tree.

The arbor-vitæ is much planted for hedges and screens, as well as for other ornamental purposes. There are many horticultural varieties. The tree is abundant in a wild state in New York.

Summary on the Kinds of Common Evergreens.

The white pine (Pinus Strobus).—Leaves in clusters of five, soft and slender; cones five or six inches long, slightly curved; bark smooth except on the trunks and larger limbs of old trees, where it is fissured.

The pitch pine (Pinus rigida).—Leaves in clusters of three, from three to four inches long, rather rigid; cones two to three inches long, often in clusters of two or more but frequently borne singly, persisting long after the seeds have been shed; bark more or less rough on the young growth and deeply fissured on the trunks of old trees.

The Scotch pine (Pinus sylvestris).—Leaves usually in clusters of two, from two to four inches long, rigid, of a bluish-green hue when seen in a large mass on the tree: cones two to three inches long and the scales tipped with a beak or prickle.

The Austrian pine (Pinus Austriaca).—Leaves in clusters of two, five or six inches long and somewhat rigid, dark green in color and persisting for four or five years; cones about three inches long, conical in shape and scales not beaked or pointed as in the Scotch pine.

The Norway spruce (Picea excelsa).—Leaves borne singly, about one inch long, dark green, four sided; cones about six inches long, and composed of thin scales, and usually borne on the tips of branchlets. The small branches mostly drooping.

The black spruce (Picea nigra).—In general appearance, this is not very unlike the Norway spruce, but the small branches stand out more horizontally and the cones are only one or one and one-half inches long, recurving on short branches. The cones persist for several years after shedding the seed.

The white spruce (Picea alba).—Leaves about one inch long, having a glaucous or whitish tinge; twigs stout and rigid, of a pale greenish white color; cones from one to two and one-half inches long, more or less cylindrical or "finger-shape," and easily crushed when dry.

The red spruce (Picea rubra).—The foliage lacks the whitish tinge of the white pruce and is of a dark or dark yellowish color; twigs stouter than those of the black spruce and not

so much inclined to droop; cones about one inch long, obovate and usually falling by second summer.

The hemlock (Tsuga Canadensis).—Leaves about one-half inch long, flat with rounded point, green on the upper side, whitish beneath, and borne on short appressed petioles; cones about three-quarters of an inch long, oval or egg-shape, and borne on the ends of small branchlets and often persisting for some time.

The balsam fir (Abies balsamea).—Leaves narrow, less than one inch long, borne singly, very numerous and standing out from the branchlets in much the way of the spruce; cones about three inches long, cylindrical, composed of thin scales and standing upright on the branches, or recurved; bark smooth, light green with whitish tinge.

The arbor-vitæ (Thuya occidentalis).—Leaves very small, scale-like and over lapping one another in four rows, adhering closely to the branchlets; the cones oblong and small,—a half inch or less in length,—and composed of but few scales.

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Deputy Chief.

June, 1899.

CORNELL

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DECEMBER, 1896, was the first issue of the nature-study leaflets. Thirteen leaflets have now appeared. Voluntary requests for these publications have now increased our mailing-list to 25,000 live names. Most of these names are of teachers in New York. In the State of New York there are 29,000 teachers.

Our entire movement in nature-study is for the benefit of the children. We are now making an effort to reach them directly, as well as through the teacher, the parent, the garden and the flower-show. We have long had correspondence with many children. Many thousands have applied to us for information on the making of gardens and on various matters connected with the common phenomena of nature ; but we are now inaugurating a definite effort at the organization of nature-clubs amongst the children of the State.

The correspondence arising from this educational work has come to be large. At present it averages over 1,200 letters a week. In a twelve-month as many as 80,000 circular letters of instruction have been sent to our correspondents. This personal correspondence will increase.

For these reasons we have adopted a new form of publication. This Bulletin will be issued four times a year, and perhaps more frequently. Each issue will contain a nature-study lesson for the teacher, and one for the children. Notes of instruction, explanation and advice, and letters from friends of the movement, will fill the remainder of the Bulletin. We desire to keep in touch with every person who has been connected with us.

This nature-study movement has grown to large proportions.

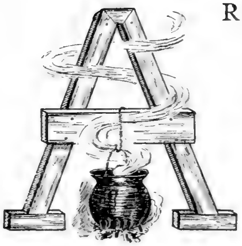
It has awakened the deepest interest. This is proof that it is needed and is founded upon correct principles. In fact, the movement is the result of current forces. It has tried to interpret them. The animus of the endeavor is to cause the child to love nature and thereby to be content with country life. There is no other corrective of agricultural ills than this. Contentment and happiness are results of thinking; and one thinks much when he sees much.

We appeal to every person who loves his kind and his country to help us. We need the coöperation. We can do nothing alone. We want to know the shortcomings and the mistakes. We want to reach every child in New York State; and we hope that others will carry the movement beyond our boundaries and make it better. When all is said and done, it will be found that the significant mark of this century is not its invention nor its learning: it is the spirit of altruism which sacrifices everything that the child may live a fuller life.

L. H. BAILEY.

A SUMMER SHOWER.

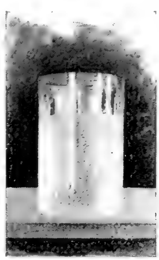
RALPH S. TARR.



A RAINSTORM comes, the walks are wet and the roads are muddy. Then the sun breaks through the clouds and soon the walks are no longer damp and the mud of the road is dried. Where did the water come from and where has it gone? Let us answer these questions.

A kettle on the stove is forgotten and soon a cracking is heard; the housewife jumps to her feet for the kettle is dry. The kettle was filled with water, but it has all boiled away; and where has it gone? Surely into the air of the room, for it can be seen issuing as "steam" and then disappearing from view, as if by magic. The heat of the fire has changed the liquid water to a gas as invisible as the air itself. This gas is *water vapor*.

Do you wish to prove that the water vapor is there, although unseen? Then if the day is cool, watch the window and notice the drops of water collect upon it. Or if the day is warm, bring an ice cold glass or pitcher into the room and see the drops collect upon it (Fig. 1). People sometimes say, when drops of water collect on a glass of cold water, that the glass is "sweating;" but see if the same thing will not happen with a cold glass that does not contain water.



1.—*A glass of cold water on which vapor has condensed in drops.*

These two simple observations teach us two very important facts: (1) That heat will change liquid water to an invisible vapor, or gas, which will float about in the air of a room; and (2) that cold will cause some of the vapor to change back to liquid water.

Let us extend our observations a little further. The clothes upon the line on wash day are hung out wet and brought in dry. If the sun is shining they probably dry quickly; but will they not dry even if the sun is not shining? They will indeed; so here is another fact to add to our other two, namely, (3) that the production of vapor from water will proceed even when the water is not heated.

This change of water to vapor is called *evaporation*. The water evaporates from the clothes; it also evaporates from the walks after a rain, from the mud of the road, from the brooks, creeks and rivers, and from ponds, lakes, and the great ocean itself. Indeed, wherever water is exposed to the air some evaporation is taking place. But heat aids evaporation, as you can prove by taking three dishes of the same kind and pouring the same amount of water into each, then placing one on the stove, a second in the sun and a third in a cool, shady place, as a cellar, and watching to see which is the last to become dry.

About three-fourths of the earth's surface is covered by water so that the air is receiving vapor all the time. In fact, every minute thousands of barrels of water vapor are rising into the atmosphere from the surface of the ocean. The air is constantly moving about, forming winds, and this load of vapor is therefore drifted about by the winds, so that the air you are breathing may have in it vapor that came from the ocean hundreds or even thousands of miles away. You do not see the vapor, you are perhaps not even aware that it is there; but in a room 10 feet high and 20 feet square there is often enough vapor to fill a two-quart measure if it could all be changed back to water.

There is a difference in the amount of vapor from time to time. Some days the air is quite free from it, and then clothes will dry rapidly; but on other days the air is damp and humid. Then people say it is "muggy" or that the "humidity is high." On these muggy days in summer the air is oppressive because there is so much vapor in it. Near the sea, where there is so much water to evaporate, the air is commonly more humid or moist than in the interior, away from the sea, where there is less water to evaporate.

We have seen that there is some vapor in all air, but that

there is more at some times than at other times. We have also seen how it has come into the air and that cold will cause it to condense to liquid water on cold window panes and water-glasses. There are other ways in which the vapor may be changed to liquid.

After a summer day, even when there has been no rain, soon after the sun sinks behind the western horizon the grass becomes so damp that one's feet are wet in walking through it. The dew is "falling." During the daytime the grass is warmed by the sun; but when the sun is gone it grows colder, much as a stove becomes cool when the fire is out. This cool grass chills the air

2.—*A wreath of fog settled in a valley with the hilltops rising above it.*

near it and changes some of the vapor to liquid, which collects in drops on the grass, just as the vapor collects on the outside of a glass of ice-water.

In the opposite season of the year, on a cold winter's day, when you step out of a warm house into the chilly air, a thin cloud, or fog, forms as you expel the air from your lungs, and you say that you can "see your breath." What you really see is the little drops of water formed as the vapor-laden breath is chilled on passing from the warm body to the cold air The vapor is condensed to form a tiny mist.

Doubtless you have seen a wreath of fog settling in a valley at night time; or in the morning you may have looked out upon a fog that has settled there during the night (Fig. 2). If your home happens to be upon a hillside you have perhaps been able to look down upon the fog nestled there like a cloud on the land,

which it really is. Such a fog is caused in very nearly the same way as the tiny fog made by breathing. The damp air in the valley has been chilled until the vapor has condensed to form tiny mist or fog particles. Without doubt you can tell why this fog disappears when the sun rises and the warm rays fall upon it.

On the ocean there are great fogs covering the sea for hundreds of miles, and making sailing dangerous, because the sailors cannot see through the mist, so that two vessels may run together, or a ship may be driven upon the coast before the

3.—*Fog clouds among the valleys in the mountains, only the moutain peaks projecting above them.*

captain knows it. Once more, this is merely condensed vapor caused by chilling air that has become laden with vapor. This chilling is often caused when warm, damp winds blow over the cold parts of the ocean.

This leads the way to an understanding of a rain storm ; but first we must learn something about the temperature of the air. The air near the ground where we live is commonly warmer than that above the ground where the clouds are. People who have gone up in balloons tell us so ; and now scientific men who are studying this question are in the habit of sending up great kites, carrying thermometers and other instruments, in order to find out about the air far above the ground.

It is not necessary, however, to send up a kite or a balloon to prove this. If your home is among mountains, or even among high hills, you can prove it for yourself ; for often, in the late autumn, when it rains where you live on the lower ground, it snows upon the hill tops, so that when the clouds have cleared away the surface of the uplands is robed in white (Fig. 4). In the springtime, or in the winter during a thaw, people living among these highlands often start out in sleighs on a journey to town, which is in the valley, and before they reach the valley their horses are obliged to drag the sleigh over bare ground. It is so much

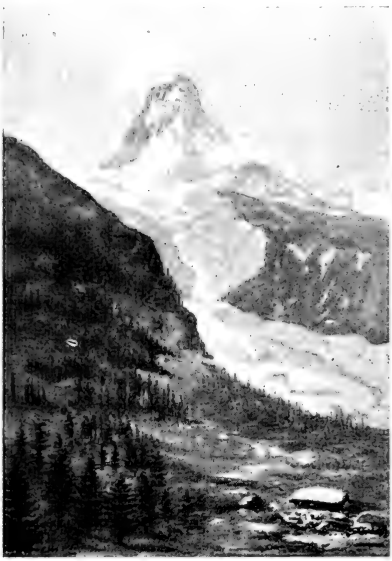
4.—*A mountain whitened by snow on the top, while there is no snow at the base.*

warmer on the lower ground that the snow melts away much more quickly than it does among the hills.

The difference in temperature is on the average about one degree for every three hundred feet, so that a hill-top rising twelve hundred feet above a valley would have an average temperature about four degrees lower than the valley. Now some mountains, even in New York, rise thousands of feet above the surrounding country. They rise high into the regions of cold air, so that they are often covered with snow long before any snow has fallen on the lowlands ; and the snow remains upon them long after it has disappeared from the lower country. Have you ever seen such a snow-capped hill or mountain ? Here is a picture of one (Fig. 4).

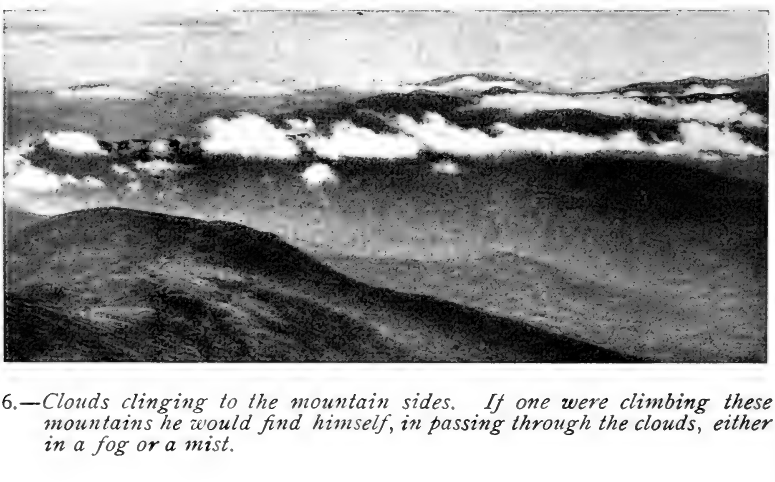
Some mountains are so lofty that it never rains upon them, but snows instead ; and they are never free from snow, even in mid-

summer ; so that if one climbs to the top of such peaks he finds it always very cold there. While he is shivering from the cold he can look down upon the green fields where the birds are singing, the flowers blossoming and the men, working in the fields, are complaining of the heat.



5.—*A mountain peak snow capped, and covered on the very crest by a cloud.*

One who watches such a mountain as this, or in fact any mountain peak, will notice that it is frequently wrapped in clouds (Fig. 5). Damp winds blowing against the cold mountains are chilled and the vapor condensed. If one climbs through such a cloud, as thousands of people have done when climbing mountains, he often seems to pass through nothing but a fog, for really many clouds are only fogs in the air above the surface (Fig. 6).



6.—*Clouds clinging to the mountain sides. If one were climbing these mountains he would find himself, in passing through the clouds, either in a fog or a mist.*

But very often rain falls from these clouds that cling to the mountain sides. The reason for this is easy to understand. As the air comes against the cold mountains so much vapor is condensed that some of the tiny fog particles grow larger and larger until they become mist particles, which are too heavy to float in the air. They then begin to settle; and as one strikes against another the two unite, and this continues until perhaps a dozen have joined together so as to form a good sized drop, which is so heavy that it is obliged to fall to the ground as rain.

Let us now look at our summer storms. These do not form

7.—*A "thunder head" or cumulus cloud.*

about mountain peaks; yet what has been said about the mountains will help us to understand such showers.

It is a hot summer day. The air is muggy and oppressive, so that the least exertion causes a perspiration, and even in the shade one is uncomfortably hot. Soon great banks of clouds appear (Fig. 7),—the "thunder heads,"—and people say "a thunder shower is coming, so that we will soon have relief from this oppressive heat." The clouds draw near, lightning is seen and thunder heard, and from the black base of the cloud, torrents of water fall upon the earth. If we could have watched this cloud from the beginning, and followed it on its course, we

would have seen some facts that would help explain it. Similar clouds perhaps began to form over your head in the early afternoon and drifted away toward the east, developing into thunder storms many miles to the east of you.

On such a day as this, the air near the ground is so damp that it gives up vapor easily, as you can prove by allowing a glass of ice water to stand on a table and watching the drops of water gather there, causing the glass to "sweat" (Fig. 1). The sun beats down upon the heated ground and the surface becomes like a furnace, so that the air near the ground is warmed.

Air that is warm is lighter than cool air, and, being lighter, will rise, for the heavy cool air will settle and push it up, as a chip of wood will rise in a pail of water, because it is lighter than the water which pushes it to the top This is why the warm air rises from a furnace, or a stove, or a lamp. It is the reason why the hot air rises through a house chimney; undoubtedly you can find other illustrations, as ventilation, and can find abundant opportunity to prove that warm air will rise.

The warm, moist air near the ground becomes so light that the heavy air above settles down and pushes it up, so that an uprising current of air is formed above the heated ground, much as an uprising current of hot air rises through the chimney when the stove is lighted. Rising thousands of feet into the sky it reaches such a height, and finally comes to a place so cool, that some of the vapor must be condensed, forming fog particles, and then makes a cloud.

On such a day, if you will watch a cloud, you will notice that its base is flat (Fig. 7); and this marks the height above ground where the temperature of the atmosphere is low enough to change the vapor to fog particles. Of course the air still rises somewhat above this base and continues to get cooler and to have more and more vapor condensed. This makes a pile of clouds resting on a level base, but with rounded tops (Fig. 7). Sometimes the base of these summer clouds, called cumulus clouds, is a mile above the ground and their tops fully a mile higher than this.

Just as on the mountain side the drops grow larger until they must fall, so here, fog particles grow to drops of such a size

that they are too heavy to float. This growth is often aided by the violent currents of air, which sometimes tumble and toss the clouds about so that you can see the commotion from the ground. These currents blow one particle against another, forming a single drop from the collision of two; then still others are added until the rain drop is so heavy that it must fall.

8.—*Photograph of a lightning flash.*

But sometimes the air currents are so rapid that the drops are carried on up, higher and higher, notwithstanding the fact that they are heavy. Then they may be carried so high, and into air so cold, that they are frozen, forming hail. These "hailstones" cannot sink to the ground until they are thrown out of the violent currents, when they fall to the ground, often near the edge of the storm.

Some hailstones are of great size; you will find it interesting to examine them. If you do this, notice the rings of clear and clouded ice that are often to be seen. These are caused when the hail, after forming, settles to a place where it melts a little, then is lifted again by another current, growing larger by the addition of more vapor. This continues until finally the ice ball sinks to the ground.

There is thunder and lightning in such storms. Few things in nature are grander than these, and those who will watch the lightning flash will see many beautiful and interesting sights (Fig. 8). Sometimes the flash goes from cloud to cloud, again from the cloud to the ground. No one knows exactly why the lightning comes; but we do know that it is an electric spark, something like that which one can often see pass from the trolley to the wire of an electric car line. The main difference is that the spark in a thunder storm is a powerful lightning bolt that

passes over a space of thousands of feet and often does great damage where it strikes.

The thunder is a sound which may be compared to the crack heard when a spark passes from the trolley, though of course the noise is very much louder. The crack of the lightning echoes and reverberates among the clouds, often changing to a great rumble; but this rumbling is mainly caused by the echo, the sound from the lightning being a loud crack or crash like that which we sometimes hear when the lightning strikes near by.

Some of the vapor of the air on condensing gathers on solid objects like grass, or glass; but some, as fog, floats about in the air. Really this too is often gathered around solid objects. Floating about in the air are innumerable bits of "dust" which you can see dancing about in the sunlight when a sunbeam enters a dark room. Some of these "dust" particles are actual dust from the road, but much of it is something else, as the pollen of plants, microbes, and the solid bits produced by the burning of wood or coal.

Each bit serves as a tiny nucleus on which the vapor condenses; and so the very "dust" in the air aids in the formation of rain by giving something solid around which the liquid can gather. The great amount of dust in the air near the great city of London is believed to be one of the causes for the frequent fogs of that city.

That there is dust in the air, and that the rain removes it, is often proved when a dull hazy air is changed to a clear, bright air by a summer shower. Watch to find instances of this. Indeed, after such a hazy day, when the rain drops first begin to fall, if you will let a few drops fall upon a sheet of clean white paper, and then dry it, you will find the paper discolored by the dust that the rain brought with it. So the rain is important because it purifies the air by removing from it the solids that are floating in it.

These are only a few of the things of interest that you can see for yourself by studying the air, Watch the sky; it is full of interest. See what you can observe for yourself. Watch especially the clouds, for they are not only interesting but beautiful (Fig. 9). Their forms are often graceful, and they change

with such rapidity that you can notice it as you watch them. Even in the daytime the colors and shadows are beautiful; but at sunrise and sunset the clouds are often changed to gorgeous banks of color.

9.—*A sky flecked with clouds high in the air.*

Watch the clouds and you will be repaid; look especially for the great piles of clouds in the east during the summer when the sun is setting (Fig. 10). Those lofty banks, tinged with silver and gold, and rising, like mountains, thousands of feet into the air, are really made of bits of fog and mist. Among them vapor is still changing to water and rain drops are forming, while violent currents are whirling the drops about, and perhaps lifting them to such a height that they are being frozen into hailstones. Far off to the east, beneath that cloud, rain is falling in torrents, lightning is flashing and thunder crashing, though you cannot hear it because it is so far away.

You see the storm merely as a brightly lighted and beautifully colored cloud mass in the sky; but the people over whom it is hanging find it a threatening black cloud, the source of a furious wind, a heavy rain, and the awe-inspiring lighting. To them it may not be beautiful, though grand in the extreme; and so too, when the summer thunder shower visits you in the early evening, you may know that people to the west of you are probably looking at its side and top and admiring its beauty of form and color.

10.—*The cloud banks of a thunder storm on the horizon.*

The storm passes on, still to the eastward, and finally the cloud mass entirely disappears beneath the eastern horizon; but if you watch, you will see signs that it is still there, though out of sight; for in the darkness of the night you can see the

eastern horizon lighted by little flashes, the source of which cannot be seen. You call it "heat lightning," but it is really the last signal that we can see of the vanishing thunder storm, so far away that the sound of the crashing thunder cannot be heard.

You watch the mysterious flashes: they grow dimmer and dimmer and finally you see them no more. Our summer shower is gone. It has done what thousands of others have done before, and what thousands of others will do in the future. It has started, moved off, and finally disappeared from sight; and as it has gone it has told us a story. You can read a part of this story if you will; and in reading it will find much that interests.

JUNIOR NATURALIST LEAFLET NO. 3.

LITTLE HERMIT BROTHER,

Cicada septendecim.

ANNA BOTSFORD COMSTOCK.

IN far Thibet exists a class of Buddhist monks who are hermits and who dwell in caves. I was told about these strange people by a Senior Naturalist, who has spent his life going around the world and finding the countries upon it as easily as you Junior Naturalists find the same countries on the globe in the schoolroom. A real naturalist is never contented with maps of places and pictures of things, but always desires to see the places and things themselves.

The Senior Naturalist told me that he found Thibet a dreary land inhabited by queer people; and the hermit monks were the queerest of all. Each one dwelt in his solitary cave, ate very little and worked not at all, but spent his time in thought. Could we read his thoughts we would be none the wiser, since they are only mysterious thoughts about mysterious things.

Now it is a surprising fact that we have hermits of similar habits here in America; only our hermits are a little people who dress in white garb and live in cells underground; they also eat little and work not at all, and probably meditate upon mysteries. However, they are equipped with six legs while the monks of Thibet have only two, a difference of little importance since neither of them travel far from their caves. * * * * *

There are places in eight or nine counties in New York State that may surely expect visitors this year. These counties are Livingston, Monroe, Onondaga, Ontario, Wyoming, Yates and those bordering on Cayuga Lake. The connection between these

coming guests and the hermits of Thibet may not seem very close at first sight ; but wait and see.

The reason why these New York counties expect company this year is that they entertained a large number of similar guests in 1882, 1865, 1848, 1831, 1814, in 1797, and probably at intervals of 17 years long before that ; however, in 1797 is the first record ever made of the appearance of these visitors. Every time they came they probably outstayed their welcome; yet they had the good quality of allowing their hosts sixteen years of rest between visits.

In order that the Junior Naturalist may recognize these visitors I will describe their methods of arrival. Sometime during the latter part of May or in early June you may hear a great buzzing in some trees as if there were a thousand liliputian buzz saws going at once. If you examine the trees you will find on them many queer looking insects, with black bodies about an inch long, covered with transparent wings folded like a roof. Naturally you will wonder how such great numbers of large insects could appear one day when they were nowhere to be seen the day before. But if you look at the ground beneath the tree you will find in it many small holes. You will also find clinging to the tree many whitish objects which at first sight seem like pale, wingless insects ; but which on closer examination prove to be merely the cast skins of insects (Fig. 11). These are the cowls and robes which our little American hermits cast off after they come out of their underground cells, and which they must shed before they can free their wings. Our little American hermits we call the Seventeen-Year Locusts. However, this name is a most confusing one, since we also call our grasshoppers locusts, and to them the name truly belongs. These Seventeen-Year Locusts are really Cicadas ; and they belong to a different Order from the locusts. The real locusts have mouth-parts formed for biting, while the Cicadas have mouth-parts grown together in the form of a tube through which they suck juices of plants. So we hope the Junior Naturalists will call our little hermits by their right name, Cicadas ; and will not permit them to be spoken of as locusts.

In order that you may know the mysterious lives of these

wonderful insects I will tell you the story of one insect which any one of you may find this summer if you live in one of the counties above mentioned.

The Story of Little Hermit Brother, Cicada septendecim.

Seventeen years ago this June, when perhaps the parents of some of the Junior Naturalists were themselves school children, a Cicada mother made with her ovipositor a little slit or cavity in an oak twig, and in this slit placed in very neat order two rows of eggs. Six weeks later there hatched from one of these eggs a pale, lively little creature, that to the naked eye looked like a tiny white ant. However, if we could have examined him through a lens, we would have found him very different from an ant; for his two front legs were shaped somewhat like lobsters' big claws, and instead of jaws like an ant, he simply had a long beak that was hollow like a tube. After he came out of his egg he ran about the tree and seemed interested in everything he saw for a time. Then, suddenly he went to the side of a limb and deliberately fell off. To his little eyes the ground below was invisible; so our small Cicada showed great faith when he practically jumped off the edge of his world into space. He was such a speck of a creature that the breeze took him and lifted him gently down, as if he were the petal of a flower, and he alighted on the earth unhurt and probably much delighted with his sail through the air. At once he commenced hunting for some little crevice in the earth; and when he found it he went to the bottom of it and with his shovel-like fore-feet began digging downward. I wonder if he stopped to give a last look at sky, sunshine, and the beautiful green world before he bade them good-bye for seventeen long years. If so, he did it hurriedly, for he was intent upon reaching something to eat. This he finally found a short distance below the surface of the ground, in the shape of a juicy rootlet of the great tree above. Into this he inserted his beak and began to take the sap as we take lemonade through a straw. He made a little cell around himself and then he found existence quite blissful. He ate very little and

grew very slowly and there was no perceptible change in him for about a year; then he shed his skin for the first time, and thus, insect-wise, grew larger. After a time he dug another cell near another rootlet deeper in the ground; but he never exerted himself more than was necessary to obtain the little food that he needed. This idle life he found entirely satisfactory and the days grew into months and the months into years. Only six times in the seventeen years did our hermit change his clothes and this was each time a necessity, since they had become too small. Judging from what the Senior Naturalist told me, I think this is six times more than a Thibetan hermit changes his clothes in the same length of time.

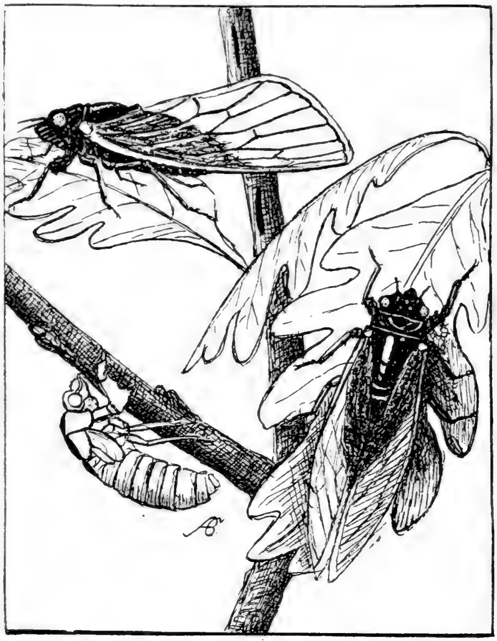
What may be the meditations of a little hermit Cicada during all these years we cannot even imagine. If any of the Junior Naturalists ever find out the secret, they will be very popular indeed with the scientific men called psychologists. However, if we may judge by actions, the sixteenth summer after our hermit buried himself he began to feel stirring in his bosom aspirations toward a higher life. He surely had no memory of the beautiful world he had abandoned in his babyhood; but he became suddenly possessed with a desire to climb upward and began digging his way toward the light. It might be a long journey through the hard earth; for during the many years he may have reached the depth of nearly two feet. He is now as industrious as he was shiftless before, and it takes him only a few weeks to climb out of the depths into which he had fallen through nearly seventeen years of inertia. If it should chance that he reaches the surface of the ground before he is ready to enjoy life he hits upon a device for continuing his way upward without danger to himself. Sometimes his fellows have been known to crawl out of their burrows and seek safety under logs and stakes until the time came to gain their wings. But this is a very dangerous proceeding, since there are many watchful eyes in forests which belong to creatures who are very fond of bits of soft, white meat. So our Cicada, still a hermit, may build him a tall cell out of mud above ground. How he builds this "hut," "cone" or "turret" as it is variously called, we do not know, but it is often two inches in height, and he keeps himself in the

top of it. Under ordinary circumstances our Cicada would not build a hut, but remain in his burrow.

Finally there comes a fateful evening when as soon as the sun has set, he claws his way through the top of his mud turret or out of his burrow and looks about him for further means of gratifying his ambitions to climb. A bush, a tree, the highest thing within his range of vision, attracts his attention and he hurries toward it. It may be he finds himself in company with many of his kind hurrying toward the same goal but they are of no interest to him as yet. Like the youth in the famous poem, "Excelsior" is his motto and he heeds no invitation to tarry. When he reaches the highest place within his ken he places himself probably back downward on some branch or twig and takes a firm hold with all of his six pair of claws and keeps very still for a time. Then his skeleton nymph-skin breaks open at the back and there pushes out of it a strange creature long and white, except for two black spots upon its back; on he comes until only the tip of his body remains in the old nymp-skin; then he reaches forward and grasps the twig with his soft new legs and pulls himself entirely clear from the old hermit garb. At once his wings begin to grow; at first they are mere pads on his back but they soon expand until they cover his body and are flat like those of a miller. The many veins in the wings are white and he keeps the wings fluttering in order that they may harden soon. If, in the moonlight of some June evening a Junior Naturalist should see a tree covered with Cicadas at this stage he would think it had suddenly blossomed into beautiful, white fluttering flowers.

As the night wears on, the color of our hero changes and his wings harden; until when the sun rises we behold him in the glory of a black uniform with facings of orange and with beautiful glassy wings folded roof-like above his body. (Fig. 11.) Great is the change wrought in his appearance during this one marvelous night, and greater still the change wrought in his habits! He is now no longer a hermit; there are thousands of his kind about him, a fact which he realizes with great joy. So happy is he that he feels as if he must burst if he does not find some adequate means for expressing his happiness in this beautiful

world of sunshine. Then suddenly he finds in himself the means of expression and bursts into song. Yet, it is not a song exactly, for he is a drummer rather than a singer. On his body just behind each of his hind wings is a kettle drum. The head to this drum is of parchment thrown into folds and may be seen with a lens if you lift his wings and look closely. (Fig. 12.) Instead of drum sticks he uses a pair of strong muscles to throw the membranes into vibration and there is a complex arrangement of cavities and sounding boards around these drum heads so that the noise he gives off is a great one indeed for a fellow of his size. So fond is he of making music that he has no time to eat or to do aught else but to sound fanfares all the sunshiny day. He is not the only musician on the tree; there are many others and they all join in a swelling chorus that has been described as a roar like that made by the "rushing of a strong wind through the trees."



11.—*The Cicada is full grown at last, and his empty nymph skin is hanging to a branch.*

12.—*The Cicada's drum.*

If our Cicada could talk to one of you Junior Naturalists he would tell you that there was a good reason for all this music. He would explain that only the men of the Cicada world possess drums and that the object and reason of all their music was the entertainment of the lady Cicadas, who are not only very

fond of this drumming but are good critics of Cicada music as well. He would perhaps tell you also that he had his eye on a certain graceful maiden perched on the leaf between him and the sun; but she on the other hand seemed to give about equal attentionto him and three other drummers situated nearby. Excited by the competition and by her indifference he rattled his drum faster and faster until he arose to the heights of Cicada melody and harmony that left his rivals far behind. Then the lady of his choice listened spellbound and pronounced him the greatest of all musicians, and thus he won his bride. However, we may safely predict that their wedded life will be too full of happiness to last. After a few weeks the sunshine, the music, the happiness of wooing and winning will prove too much for our hero and one day he will beat his drum in a last mad ecstasy and fall to earth and die from happy exhaustion. His little wife may survive him only long enough to cut some slits in some of the twigs of the home tree and place in them rows of eggs from which shall develop a family of hermits which shall come forth and fill the world with their music seventeen years hence, when our Junior Naturalists are men and women grown.

There are many broods of the Cicadas in the United States so that they appear in different localities in different years. New York State has five well-marked broods: one in the western counties is due in 1900; a large brood on Long Island and near Rochester will appear in 1902; another on Long Island in 1906; another in the Hudson River valley in 1911. The brood which we ask the Junior Naturalists to study this summer is limited to central New York and northern Pennsylvania and is called Marlatt's brood No. VII., or Riley's brood No. XIX. As it was observed first in 1797, you see this race was an "old settler" in central New York and was doubtless here many years before the Pilgrim fathers landed at Plymouth. So when the Junior Naturalists of central New York observe the Cicada this summer let them count back and see how few generations of them have passed since only Indians listened when they came forth from their caves and beat out their short lives in song.

There are several other species of Cicada peculiar to America. One is called *Cicada tredecim* since it appears every thirteen years. However, this species is limited to the south.

The Dog Day Harvest Fly, or Lyreman, is the Cicada that is best known to us through the northern and middle states. This appears in small numbers every year and is a distinct addition to the summer chorus of insect singers. He is larger and much more dignified in appearance than is his cousin *septendecim*. He wears a black suit embroidered with scrolls of dark olive green and the whole lower surface of his body is covered with white powder. His drums are situated above plates which may be seen on the lower side of the body, one behind each hind leg. He hides in trees and his shrill music is so associated with the heat of summer noons that the sound itself makes one drowsy. The hermit life of the lyremen in underground cells is supposed to last only two years.

While the Cicadas of which we have spoken are the children of an ancient race which inhabits America, Europe also has her ancient races of Cicadas, although they are not the kind who live hermit lives for seventeen years. We have evidence that their music was held in high esteem by the ancient races of men—especially the Greeks. When Homer complimented his orators he compared them with Cicadas. Thus it may lend a special interest to the study of the Cicada by our Junior Naturalists when they know that his kettle drums have been celebrated instruments of music by poets who wrote three thousand years before America was discovered by Columbus.

Queries for Sharp Eyes.

When did you first see one of the Cicadas?

What was it doing when you found it?

Did it do anything to attract your notice to it, or did you find it by accident?

Where did you find it?

See if you can determine which are the father and which the mother Cicadas.

Try to find where a mother Cicada has laid some eggs.

If you find where the Cicada emerged from the ground, or from a hut, give a brief description of the location, as to kind of soil, etc.

Where did you find the most of the cast off nymph skins?

Did you discover animals or birds feeding upon the Cicada?

NOTES FOR JUNIOR NATURALISTS.

JOHN W. SPENCER.

Be it hereby known, that

....

Junior Naturalist Club
is organized under the care and direction of the Cornell University College of Agriculture;

And that, its purpose is the Study of Nature, to the end that every member thereof shall love the country better and be content to live therein;

And further that this Document is a Charter acknowledging said Club to be a part in the Extension Work in Agriculture, inaugurated under the Laws of the State of New York.

The foregoing picture represents on a small scale the charter which we give to Junior Naturalist Clubs. A seal is attached to each charter. On the right is the tower of the Cornell University Library. The Library itself is an immense storehouse of books, containing about 225,000 volumes, besides many periodicals. It is a great factor in University life and work. The University buildings are dotted about the campus, resembling a scattered village; but all have a path leading to the Library. On the left of the picture is the country schoolhouse, and between that and the Library tower letters will be seen passing back and forth. These are to bind in closer sympathy the University and every common school of the country.

We want every child to form a Junior Naturalist's Club, or to be a member of one. We wish it to be an actual and active club where you can help each other to see the common things about you. We want you to be real naturalists in a boy and girl way. We shall help you to get as much fun out of it as can be found in fishing, and as much wisdom as can be found in a big book. You will not be asked to study books very much, but to see the things themselves. All boys and girls can join the club, and those doing required work will receive a badge button.

The first step for you to take toward organizing such a club is to ask all boys and girls, who wish to join, to sign their names to a list for membership. Then call a meeting of all members for election of officers, consisting of a president, secretary and treasurer, and for choosing a name for your club. Your secretary can write us an account of the proceedings of your meeting, giving us the names of your officers and those of your members, and we, in return, will send a charter showing that we recognize you as working under our direction. With the charter we shall send you some directions for beginning work, the first step of which will probably be to go to the fields and woods for some material for study. Perhaps your teacher will permit you to bring this material to the schoolroom where you can observe it closely from time to time.

Most clubs have weekly dues. We shall expect dues from each member, not in money, but a letter, written each week, telling us what new things you have learned. If you prefer to send

us drawings instead of a letter, we shall accept them for dues. In some grades, your teacher may wish you to do this as "busy work;" or, if she prefers, you can make your nature-study the topic for your language or drawing lessons. Whichever you do, we hope you may be permitted to write as you would talk. We do not care to know so much about your scholarship as to learn your way of thinking and seeing.

The letters that we receive from members of the Junior Naturalist Clubs are very interesting, and we find that there are many ways in which they regard the same questions. Some seem to think that "to get the answer" the quickest way possible is all that is necessary. Such answers do not mean much and we are not satisfied with them, because they show very little thought.

After a busy day's work, I often walk home by a path that leads me across a high bridge, where it is a great rest to lean on the railing and gaze into the gulf beneath. The hemlocks, whose tips do not reach as high as the floor of the bridge, spread their boughs until they partially screen the bounding waters on the rocky stairs beneath. I think of other days when a comrade joined me in the same pleasure of a five minutes' silent contemplation. If you ask me what I see in that chasm that rests me so much, I might tell you that I am watching the water run down hill. This would be "giving an answer," yet it would not express what I feel and what is really to be seen in the shadowy depth.

Some of the letters tell us the number of legs which a tent caterpillar has, the stripes on its back, and all that kind of detail, and so far as it goes it is all right. What we want, however, is more thought given to the subject. Besides learning all we can about it in its present condition, we must look upon the caterpillar as the second link of a chain containing four parts. To understand some of the marvels of its life, we must understand Nature's method of causing each link to be a preparation for the following one.

The only way this insect survives our severe storms of winter is in the egg state. These eggs are covered with a thick coat of varnish which furnishes a protection as effective as that protecting the paint on the finest coach. The varnish on President Mc Kinley's carriage is of no better quality than that which the

mother puts upon these eggs. The eggs do not hatch until food, in the form of young buds, appears. When left to natural conditions, the buds and the caterpillars develop together and one never precedes the other. As the hairy fellows increase in size and demand more food, the foliage expands to meet the increased demand for forage. The Junior Naturalist who simply works "to get the answer" fails in getting this interesting part of the lesson.

What are the four stages in the life of the tent caterpillar?

By the time this meets the eyes of our Junior Naturalists, there will have appeared in the counties of Livingston, Madison, Monroe, Onondaga, Wyoming and Yates in this State the seventeen-year locust or, more properly speaking, Cicada, about which Mrs. Comstock has charmingly told you elsewhere. We have a number of Junior Naturalists in these counties, and we shall ask them to make observations upon this visitor and send their reports to us for publication in a future number. A close reader of Mrs. Comstock's article will see that these Cicadas are really insects, that spend their lives in the ground for 17 years and come out to the air and sunshine only to prepare eggs for another brood, and not to eat. The only damage they do is to kill the tender shoots of trees where eggs are deposited. When this occurs on trees nearly full grown, the damage is very slight. We wish to call your attention to what is said about the manner in which the male produces a call for his mate. When in large numbers the united sounds make an impression one will never forget.

Following is a list of the Junior Naturalist Clubs organized up to May 24, 1899. Some of the Clubs have not yet sent us the names of officers :

CORNELL JUNIOR NATURALIST CLUBS.

TOWN.		PRESIDENT.	SECRETARY.	TREASURER.
New Dorp,	N. Y.	Edna Nichols	Mable Wolfenden	Emily Duval
Margaretville,	"	Dora Race	Augusta Kaufman	
S. Schodack,	"	Mamte A. Meehan	Charlotte Shufelf	
Snyder,	"	Allen Wetzel	Elmer Pardee	Grace Fogelsonger
Sherburne,	"	Sarah A. Gardiner	Carrie S. Gorton	Chas. W. Gorton
Gilbertsville,	"	Lena Camp	Walter Davis	Chas. Brewer
Wilson,	"	Lotta Coombs	Edna Tenbrook	Grace Johnson
Cazenovia,	"			
Cazenovia,	"			
Cazenovia,	"			
Cazenovia,	"			
Cazenovia,	"			
Cazenovia,	"			
Cazenovia,	"			
Catskill,	"		Jno. L. Fray.	
Freeport,	"		S. F. Johnson	
Freeport,	"			
Freeport,	"	Herbert Tredwell	Madeline Oley	Florence Rhodes
Tarrytown,	"	Joseph Murphy	John Leonard	Dora Behrens
Stockton,	"	Jessie Wakeman	Louis Cutting	
Richfield Spa.,	"	Willie Mason	Lizzie Evans	
North Urbana,	"	Stella Gleason	Carl Gleason	Edmond Gleason
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MISCELLANEOUS NOTES.

HOME NATURE-STUDY COURSE.

A Home Nature-Study Course for teachers has been established for the benefit of those who wish to carry on a line of study in connection with their teaching, and through vacation, but who cannot undertake the work of a summer school.

The course consists of printed matter selected for the purpose from the publications of the Bureau of Nature-Study, together with a quiz. This quiz is a series of questions, but should be regarded as a report of progress and not as an examination.

Lesson 1 on the germination of seeds is already in the hands of some five hundred teachers. Lesson 2 is on the subject of life in an aquarium with special reference to the study of the development of the toad and the frog. Both lessons will be sent on application, and others will follow as issued.

It is hoped that groups of teachers in one school or locality, training classes, and others preparing to teach, will take up this Home Nature-Study Course.

SYNOPSIS OF THE EXTENSION WORK.

The State Extension Work in Agriculture prosecuted by the College of Agriculture of Cornell University, proceeds along the following lines :

I. *Coöperative experimentation*, the results of which are reported in the regular bulletins of the Station.

II. *Nature-Study and Farmer's Reading Course.*—The Nature-study movement proceeds along several lines, of which the following are chief :

(1.) Efforts to reach the children through the teacher, by means of :
- Teacher's leaflets.
- Instruction at teachers' institutes.
- Instruction at State summer schools.
- Instruction in a school of nature-study at Cornell University.
- Home nature-study course.
- Personal correspondence.

(2.) Efforts to reach the children directly, by means of :
- Naturalist clubs.
- Children's leaflets.
- Making of gardens.
- Collecting of insects.
- Holding of flower-shows.
- Personal correspondence.

Correspondence may be addressed to *Bureau of Nature-Study*, Ithaca, N. Y.

L. H. BAILEY, Chief.

JOHN W. SPENCER, Deputy Chief.

CORNELL READING-COURSE FOR FARMERS.

READING-LESSON
NO. I,
NOVEMBER, 1898.
2D EDITION.

BY L. H. BAILEY.

The Soil: What it Is.

1. *The basis of soil is fragments of rock.*—As the earth cooled, the surface solidified into rock. The processes of nature have been constantly at work in breaking up this rock and making it into soil.

2. *Weathering is the great agency in making rocks into soil.*—Rain, snow, ice, frost have worn away the mountains and deposited the fragments as soil. Probably as much material has been worn away from the Alps as still remains, and this material now forms much of the soil of Italy, Germany, France, Holland. Our own mountains and hills have worn away in like manner.

3. *Weathering is still active.*—All exposed rocks are wearing away. Stones are growing smaller The soil is pulverized by fall plowing.

4. *The particles of soil are worn and transported by water.*—Every stream carries away great quantities of soil and deposits it in the shallows and the bays. After every rain, the streams and ponds are muddy or roily. Observe the sediment or fine mud which remains when a "mud-puddle" dries up. The smallest rivulet carries away tons of earth every year; and this earth is deposited somewhere, and sometime it may, perhaps, come into use again for the growing of plants. Many of our best and richest farm lands are the deposits of former streams and lakes. Such lands are fine and silt-like. Most lowlands belong to this category; and even some of our higher lands are formed from deposits from water. The mixed and varied character of soils is largely due to the fact that they are the results of transportation from different places.

Observe the flat lands about lakes. These flats are formed by the deposition of material from the surrounding highlands; but they are often exposed before their natural time by the lowering of the water level in the lake. All lakes and ponds are filling up. Nearly every stream makes a delta at its mouth; but if the stream into which it empties is swift, the delta may be carried away.

Observe also, the broad rounded hillocks and knolls in valleys and ravines. Many of them have attained their present form from the action of moving water.

Every farmer knows that overflowed lands are rich. He has heard of the wonderful fertility of the Nile. He should explain these facts.

5. *All productive soils also contain organic matter.*—Organic matter is the remains of plants and animals. As found in soils in a decaying condition, it is called humus. It is the humus which gives the soil its dark or "rich" look. It also tends to make soils loose, warm and mellow. It holds moisture. The addition of humus makes soils loamy. A sandy loam is a soil of which the original mineral matter is sand, and a clayey loam is one of which the basis is clay. Soils which have no humus are hard, "dead" and unproductive.

6. *Humus is supplied by means of roots and stubble, green-crops and barn manures.*—If the farmer practices a rotation of which meadow and pasture are a part, the supply of humus will be maintained. In such cases, green-manuring is unnecessary except now and then upon lands which are very hard or poor. The roots and stubble, with the droppings of the animals on the pasture, and manure applied with one of the crops in the rotation, keep the land well supplied with vegetable matter. Whenever possible, it is better to feed the crop to stock and return the manure to the land, than to plow the crop under; for one will get back the greater part of the fertilizing value of the crops and maintain the animal at the same time. In western New York, there are hundreds of acres of refuse lands, and at this day there are thousands of tons of herbage on the ground, and no stock to eat it. It is wasteful.

Many soils which are said to be worn out are robbed of their humus rather than of their plant-food; others have been injured

in their texture by careless or faulty management. In supplying humus, it is better to add small quantities often. Lands which are under constant tillage, in corn, wheat, oats, potatoes, may be supplied with humus if catch crops are sown with the crop, now and then, late in the season. Rye, Canada peas, crimson clover, and the like may be used for this purpose. Plow them under as soon as the land is ready in the spring, even if the plants are not large.

Observe how the forest supplies its humus. Year by year the leaves add to the soil cover, slowly passing into vegetable mold or humus. The trunks finally decay and pass into the soil. The work is effectively done, but it consumes time; and man is in a hurry. When the forest is removed, the land is very productive. It is called "virgin soil," notwithstanding the fact that an enormous crop of trees has just been taken from it, and that it may have grown hundreds of such crops. The real virgin soil is the barren soil. But however rich this forest soil may be when the timber is first removed, it generally soon loses its exhuberant fertility. The pigmy crops of the farmer seem to be harder on the soil than the gigantic crops of Nature. Some of this loss of productivity is due to the loss of humus.

A rotation prevents the exhaustion of plant-food, supplies nitrogen in leguminous crops, one crop leaves the land in better condition for another, the roots and stubble improve the texture of the soil, it keeps weeds in check, provides for continuous labor because stock is kept.

The rotation should differ with the kind of soil and general style of farming. The Cornell rotation is:

Wheat,
Clover and timothy, 1 year,
Maize (corn),
Oats.

A good rotation for weed-infested land is:

Sod, 1 year,
Maize,
Potatoes, or some other tilled crop.
Oats or barley.

On fruit farms, rotations are not so practicable as on grain farms; but the fields which are not in fruit can often be worked in rotation to great advantage. The general tendency of fruit-farmers is to keep too little stock. If stock cannot be kept, the humus can be maintained by catch-crops and cover-crops.

7. *The fertility of the land is its power to produce crops. It is determined by three things: the texture of the soil, its richness in plant-food, and its available moisture.*—The texture of the soil is its physical condition,—as to whether it is mellow, loose, leachy, cloddy, hard, and the like. A rock or a board will not raise corn, and yet it may contain an abundance of plant-food. The plant cannot get a foothold; and it would do no good to apply fertilizers. Spreading potash on a lump of clay is not farming: it is the wasting of potash. A cow will not appreciate the fanciest ration if she is uncomfortable; neither will a plant. It is only on land which is in good tilth that fertilizers pay. The better the farming, the more it will pay, as a rule, to buy plant-food; but poor farmers cannot make it pay.

8. *Nature secures good texture in soil by growing plants in it.*—Roots make the soil finer, and plants supply it with humus. Plants break down the soil by sending their roots into the crevices of the particles, and the root acids dissolve some of it. Observe Nature working at this problem First the "moss" or lichen attacks the rock; the weather cracks it and wears it away; a little soil is gathered here and there in the hollows; a fern or some other lowly plant gains a foothold; year by year, and century by century, the pocket of soil grows deeper and larger; and finally, the rock is worn away and crumbled, and is ready to support potatoes and smart-weed. Or, the rock may be hard and bare, and you cannot see any such process going on. Yet, even then, every rain washes something away from it, and the soil beneath it is constantly receiving additions. Some soils may be said to be completed: the rock is all broken down and fined. Other soils are still in process of manufacture: they are full of stones and pebbles which are slowly disintegrating and adding their substance to the soil. Did you ever see a "rotten stone?"

The longer plants are grown on any soil, and returned to it, the richer the soil becomes. But Nature has centuries at her

disposal; man has but a few short years and must work rapidly, and he cannot afford to make mistakes.

9. *The texture of the soil may be improved* (1) *by underdraining* (2) *by tilling* (3) *by adding vegetable matter* (4) *by adding certain materials, as lime, which tend to change the size of the soil particles.*—The reader will say that Nature does not practice tile-draining. Perhaps not; but then, she has more kinds of crops to grow than the farmer has, and if she cannot raise oaks on a certain piece of land she can put in water-lilies. We shall have an entire lesson devoted to drainage and tillage, and also one to manures and fertilizers. It is enough for the present to say that the roots which are left in the ground after the crop is harvested are very valuable in improving the soil. This is particularly true if they are tap-roots,—if they run deep into the soil. Clover bores holes into the soil, letting in air, draining it, warming it and bringing up its plant-food. Roberts reports ("Fertility of the Land," p. 345) that a second growth of clover, two years from seeding, gave a yield of air-dried tops of 5,417 lbs. per acre, and of air-dried roots 2,368 lbs. in the first eight inches of soil. Add to this latter figure the weight of roots below eight inches and the stubble and waste, and it is seen that the amount of herbage left on the clover field is not greatly less than that taken off. In this instance, the roots contained a greater percentage of nitrogen and phosphoric acid than the tops, and about the same percentage of potash.

Make an estimate of what proportion of the plant growth you raise is actually taken off the field. Figure up, as accurately as you can, the portion left in roots, stubble, leaves, and refuse. Even of maize, you do not remove all from the field. This calculation will bring up the whole question of the kind of root-system which each sort of plant has. Have you ever made a close examination of the roots of potatoes, maize, wheat, clover, cabbages, buckwheat, strawberries, Canada thistles, or other crops? From what part of the soil do these plants secure their nourishment? What power have they of going deep for water? What proportion of them is root? Because the roots are hidden, we have neglected to examine them.

10. *The soil is plant-food; but this food becomes usable or avail-*

able slowly.—Roberts has compiled the analyses of 49 representative soils, made by American chemists, and the following is the result: "The tables reveal the fact that even the poorer soils have an abundance of plant-food for several crops; while the richer soils in some cases have sufficient for two hundred to three hundred crops of wheat or maize. The average of 34 analyses gives to each acre of land, eight inches deep, 3,217 pounds of nitrogen, 3,936 pounds of phosphoric acid, and 17,597 pounds of potash, and this does not include that which is contained in the stones, gravel and sand of the soil which will not pass through meshes of one fiftieth of an inch, which, by weathering and tillage, slowly give up their valuable constituents.—*Roberts*' "*Fertility of the Land,*" p. 16.

Fortunately, this great store of plant-food is locked up, else it would have leached from the soil or have been used up long ago. By careful husbandry, a little of it is made usable year by year; and the better the management of the land the more of this food is available to the plant. When the farmer has done his best to get out of the land all that it will give him, then he may add fertilizers for bigger results.

Plant-food is available when it is in such condition that the plant can use it. It must be both soluble and in such chemical form that the plant likes it. Plant-food which is not soluble in rain water, may still be soluble in soil water (which contains acids derived from the humus); and the acid excretions from the roots may render it soluble. But solubility is not necessarily availability, for, as we have said, the materials must be in such combination that the plant will take them. Thus, nitrate of soda ($Na\ NO_3$) is available because it is both soluble and in the form in which the plant wants it. But nitrite of soda ($Na\ NO_2$) is not available although it is soluble,—the plant does not like nitrites.

11. *Nitrogen must probably be in the form of nitrates before it can be used by most plants.*—Nitrogen is abundant. It is approximately four-fifths of the atmosphere, and it is an important content of every plant and animal. Yet, it is the element which is most difficult to secure and to keep, and the most expensive to buy. This is because the greater part of it is not in a form to be avail-

able, and because, when it is available, it tends to leach from the soil. It is available when it is in the form of a nitrate—one part of nitrogen, three parts of oxygen, united with one part of some other element (Na NO_3, nitrate of soda; K NO_3, nitrate of potash or saltpetre; H NO_3, nitric acid, etc). The process of changing nitrogen into nitrates is called nitrification. This process is the work of germs or microbes in the soil; and these germs work most efficiently when the soil is not water-logged, and when it is well tilled. The farmer should make his nitrogen supply as he goes along; and he makes it with tile drains, plows, harrows and cultivators.

But there are some plants which have the power of using the nitrogen which is in the air in the soil. These are leguminous plants,—clovers, peas, beans, vetch, alfalfa. If therefore, the farmer cannot secure sufficient nitrogen by other means, he may use these plants as green-manures. If his system of farming will not allow him to use these plants, or if he does not secure sufficient nitrogen when he does use them, then he can go to the warehouse and buy nitrogen.

12. *The soil is not a mere inert mass: it is a scene of life and activity.*—This is the new and the true teaching. Soil which is wholly inactive is unproductive. Movements of air and water, actions of heat and evaporation, life-rounds of countless microscopic organisms, decay and disintegration of plants and soil particles,—these are some of the activities of the fertile soil. If our ears were delicate enough, we could hear the shuffle of the workers, the beating of the hammers, and the roll of the tiny machinery. All things begin with the soil and at last all things come back to it. The soil is the cemetery of all the ages, and the resurrection of all life. If the soil is not idle, neither should the farmer be.

NOTE. Persons who desire to pursue this subject further should procure King's book "The Soil," and Roberts' "Fertility of the Land." Published by the Macmillan Co., New York, at 75 cents and $1.25 respectively.

This Reading-Lesson is sent free to all persons in New York State who are interested in agriculture. A supplement or quiz accompanies it, asking questions on the Lesson. Those who answer these questions will receive subsequent issues of Lessons. These Lessons are published by the College of Agriculture, Cornell University.

Address,
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Cornell University,
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Or,
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John W. Spencer,
Deputy Chief.

SECOND EDITION.

CORNELL READING-COURSE FOR FARMERS.

QUIZ ON READING-LESSON NO. I.

NOVEMBER, 1898

BY JOHN W. SPENCER.

These questions constitute a supplement to Reading-Lesson No. 1 ("The Soil: what it is"). Its purpose is to induce the reader to think carefully about what he reads. Answer the questions as best you can and return this sheet to us (2 cents postage). We want these answers in order that we may know what interest you are taking in the Reading-Course and how much good you are getting from it; and we want to help you when you do not understand the problems involved. We are after results, and do not care about the handwriting nor the grammar. These answers are for our own examination and are not to be made public. We should be glad of any comments on these lessons.

It is hoped that readers will form themselves into little clubs, to meet once or twice a month to discuss the problems raised by the lessons.

Those who answer the questions will receive future lessons.

Have you ever observed the influence of weather upon soft, slaty rock jutting out on embankments and in railroad cuts?

Have you ever taken a glass of muddy water from a flowing stream and allowed it to stand until the sediment had settled? What is this sediment?

Imagine a branch of this stream bringing rotted slate rock and another bringing fine sand. When mixed in the main stream and deposited on some bar or overflowed field, what kind of soil would the mixture make?

What is inorganic matter?

What is organic matter?

Why are soils from which a thrifty forest growth has been removed capable at once of producing good farm crops?

Have you ever observed lichen (sometimes called "moss") growing on bare rock or on a tombstone?

If any great amount of lichen should become mixed with the disintegrated rock, would it be humus and form a weak soil that might produce an order of plants a little larger and stronger than lichen?

As the higher order of plants come in and die down and mix with the soil, would the process increase the productive power of the soil?

In instances in which soil has been removed by grading, could a new soil be well made by adding commercial fertilizer alone? What would you apply first to such land?

If humus in soil under cultivation is perishable, ought it not to be the farmer's first care to keep good the quantity first found in the virgin soil?

In addition to the humus returned to the soil in manure, from forage fed to stock, and by plowing under stubble and roots, do you think it a good plan to sow some cover-crop in corn rows at last cultivation, and on oat and wheat stubble as soon as the crop is off, for plowing under the following spring?

What are good crops for this purpose?

Which of these are leguminous plants? Name all the kinds of leguminous plants you know?

Why is it advised to plow under the green-crops as soon as the land can be worked in the spring?

Do you think a rotation of crops helps the soil to bear the strain of successive cropping? If so, why?

Are you aware that plant-food exists in the soil in both available and unavailable forms, and that when plants have used up most of the available portion we call the soil worn out?

Is it true that your soil is capable of being made an active laboratory in which changes will take place and some of this unavailable plant-food be made usable?

Are you aware that when the texture of your soil is poor, or, in other words, when your laboratory is out of order, the best commercial fertilizers or stable manures will not give the best results?

Do you know that heat and air are important agencies in the changes going on in the soil, as they also are in the changes in a barrel of cider or in the yeast in a pan of dough?

Does standing water on soil have a detrimental or beneficial effect on the heat and air? Why?

How can you make the soil laboratory do the best work?

Name..

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CORNELL READING-COURSE
FOR FARMERS.

READING-LESSON
No. 2.
DECEMBER, 1898.

By JOHN W. SPENCER.

TILLAGE AND UNDER-DRAINAGE: REASONS WHY.

1. *The difference between black and white.*—Two farmers are neighbors. Mr. White has made a study of potato culture for a number of years, and, as a result, now has an average yield, one year with another, of about 200 bushels per acre from a field of three to five acres. Mr. Black is considered a fairly good farmer, as farmers go, but has given potato culture no special study. He manages his crop as his neighbors do. His methods are those which have been a tradition for several generations, and they had their origin when the country was new and high cultivation was impossible on account of the stumps and lack of tools, and also because the virgin soil made it unnecessary. His annual yield is not far from 60 bushels per acre. In other words, Mr. Black has to plow, harrow, furnish seed, plant, and cultivate about ten acres to secure as many potatoes as Mr. White does from three acres. Both men sell their product to the same dealer, and we will assume that they receive the same price per bushel. The cost of producing a bushel of potatoes must be very much more with Mr. Black than it is with Mr. White. No manufacturer or merchant could withstand the keen competition in trade if handicapped as Mr. Black is. When the respective farms were reclaimed from the forest, they were considered to be alike in character of soil, and the rain falls impartially on each.

Why the difference in cost of production between Black and White? There are many points of difference in their methods, but we are free to say that one of the essential differences is in tillage.

2. *The plant needs water.*—When Mr. White contemplates a crop of potatoes, he proceeds to make an estimate of what the

crop will require and how he can provide for that demand. Perhaps the greatest of all needs is water. By turning to Cornell Experiment Station Bulletin 120, page 419, it will be seen that in a dry season a bushel of potatoes requires about three tons of water for its production. If Mr. White expects 200 bushels of potatoes per acre, he must somehow manage to provide 600 tons of water for each acre. He has no facilities for irrigation, and his only resource is to make the soil a reservoir. He must store the supply left by winter snows and spring rains, and also the irregular rainfall that comes during the season's growth. Speaking in broad averages, in soils most commonly met with, this storage possibility amounts to about 300 tons of water per acre in the first eight inches of the soil. It must be understood that this amount is not in the form of standing water, for water standing in the soil for any length of time injures both soil and plant.

3. *The most useful form of water for plants is film moisture.*—Water is capable of assuming many forms, such as steam, vapor, ice, or free-moving liquid. The condition most valuable in the soil is none of these, but is in the form of film moisture. This film moisture can be shown by dipping a marble into water and observing the film of water surrounding it on all sides. When each soil-grain is covered with film moisture, as the marble is, the ideal conditions of soil moisture exist. This form of water is largely independent of gravitation and travels readily in all directions, as can be seen by dipping a cube of sugar into a spoonful of coffee. It is capable of transporting plant-food to the roots of plants from remote corners, where the roots do not reach.

It will be observed that film moisture is held only on the surface of soil-grains. The more the soil is pulverized, the more soil-grains there will be, and therefore the greater amount of surface to hold film moisture.

The difference in the capacity of lumpy and fine soils to hold film moisture is surprising to one who has not given the question study. George W. Cavanaugh, assistant chemist at the Cornell Experiment Station, has very graphically shown this by the following experiment: He put some small marbles in a tumbler, as shown by Fig. 1, and the total amount of film moisture that the

marbles would carry is represented in the tube placed beside the tumbler. The soil in the other tumbler (Fig. 2) is of the same weight as the marbles in Fig. 1, and it represents the marbles reduced to the fineness of common sand. Its capacity for holding film moisture is represented by the water in the standing tube (Fig. 2). The weight of material is the same in each tumbler, and the reason why one holds three times more film moisture than the other is due to the increase of surface that comes by dividing a coarse lump into fine particles.

The marbles represent the careless tillage of Mr. Black, and the finer particles the thorough tillage of Mr. White. Mr. White plows about one-third deeper than Mr. Black, and thereby makes another addition to the capacity of his reservoir.

The coarse soil, as represented by the marbles, will lose its film moisture by evaporation much more readily than the soil represented by Fig. 2, particularly if the surface of the latter is covered by fine particles representing an earth-mulch.

4. *Tillage makes plant-food available.*—Another difference in the culture given by Black and White is that the better tillage enables the plant to realize more food from all fertilizers which may be applied. There is also a benefit in making available some of the plant-food that nature has put in the soil. Broadly stated, the native plant-food amounts to as much as can be bought in $2,000 worth of commercial fertilizers. The finer soil has another advantage in affording a greater area for root pasturage. It is not uncommon for farmers to think of plant-food in the soil as in the condition of salt or sugar which is capable of

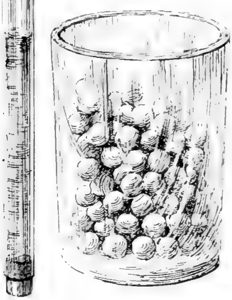

FIG. 1.—*Water held by a coarse soil.*

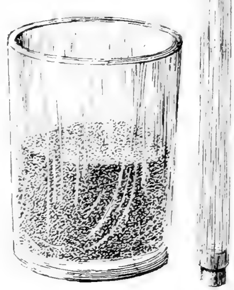

FIG. 2.—*Water held by fine soil.*

being immediately dissolved by water and at once appropriated by the plant, or like potash in ashes that can be soaked out. Plant-food exists in this form only to a limited extent. A man might famish if locked up in a granary filled with wheat; yet, a chemist would say that there was enough food near him to feed a hundred men. This illustrates how nature has stored much of the plant-food in the soil. It has to go through many changes before it can be appropriated by the plant. The soil is a factory in which the work of preparation is carried on.

5. *The soil is a laboratory.*—Some of the agents employed in this factory are film moisture, air and heat; and if these are not furnished in the proper extent and manner, the factory runs in a sluggish way, if it does not stop altogether. Good tillage does much to hasten the activities of this factory by allowing free ingress to the soil of film moisture, air and heat. Air is necessary for a supply of oxygen, and heat to facilitate fermentation and other vital processes.

The importance of air and heat in the soil brings us to the question of drainage. Air cannot enter a soil freely which is filled with standing water, and growth of micro-organisms is stopped.

6. *Wet soils are cold.*—Standing water is a great absorbent of heat. If no provision is made to drain it away, it must be evaporated away. Thereby heat is lost. The soil is cold. A great many barrels of water can be standing on an acre of ground and not attract much attention.

To appreciate the amount of heat necessary to evaporate water one has only to chop, split and burn beneath a caldron kettle enough wood to evaporate a barrel of water. Every barrel that is evaporated from the soil by the sun absorbs as much heat as is contained in the wood used under the kettle. The soil and plants are perhaps chilled for want of that heat. This is the reason that a wet soil is said to be cold.

7. *Drained soils resist drought.*—Some farmers have the notion that well drained soil will not withstand a drought as well as an undrained soil. The contrary is true. Everyone who has tilled the soil is familiar with places that are wettest in a wet time and driest in a dry time. When these places dry at all, they

dry like a brick. A wet soil can never be tilled so as to present the greatest amount of surface for film moisture and give it a mellow texture to receive a gentle saturation of air; and standing water robs it of much heat required by the soil and plants.

8. *Drainage makes a soil reservoir.*—There is a place in every soil at which the free water stands. This place is called the water-table. It may be three inches down, or a hundred feet. It is the bottom of the soil reservoir, the bottom of our dish-pan. This dish-pan, or the upper and tillable soil, is the reservoir. It is the part in which the water is held as films on the soil particles. These films travel from particle to particle, the general tendency being upward because the moisture is passing off near the top of the soil by means of evaporation and appropriation by plants. Moisture is constantly supplied from the water-table below. We speak of this movement as capillary attraction.

Under-drainage lowers the water-table. It lowers the bottom of the dish-pan; and thereby there is a deeper reservoir above it for the holding of film moisture and the distribution of roots.

But, the reader says, if the water-table supplies moisture to the upper soil, then it must be useful and necessary. Certainly; but it must not be too high, for roots of farm plants do not thrive in standing water. If the upper soil is well tilled, capillary attraction will bring the moisture up.

9. *Do not let the moisture get away.*—We want this film moisture in the upper soil in order that roots may use it. The plants do not use it, to any extent, after it has passed off into the atmosphere. Therefore, stop this water before it reaches the atmosphere.

How? Put a layer of loose dry earth between the moist soil and the atmosphere. This layer will stop the upward capillary flow (see Caption 3). This layer is the earth-mulch. It conserves, or saves, moisture.

10. *Dry and hard soils may be benefited by under-drainage.*—The water-table is lowered. Air is admitted. The soil does not puddle. It becomes fine. Under-drainage makes wet soils dry by removing the free water; it tends to make dry soils moist by deepening the reservoir and fining the particles of soil.

11. *What tillage tools are for.*—Some tools, as plows, are to

mellow up the soil and to deepen the moisture reservoir. Others, as cultivators, are to tear up and to pulverize the soil to greater or less depths. Cultivators lift and turn the soil. The spring-tooth harrow is really a cultivator. Other tools, as harrows, prepare the surface of the soil. They make the seed-bed and put on the earth-mulch. The true harrows stir the soil, but do not lift or invert it.

12. *Weeds do not like well-tilled lands.*—The first and greatest value of tillage is to put the soil in such condition that plants can grow, and then to keep it so. Incidentally, it prevents from growing those plants which we do not want,—the weeds. Usually, the process is reversed: weeds make us till, and we get the other benefits without knowing it. The best tillage prevents weeds rather than kills them.

13. *Summer-fallowing is a means of cleaning land and of correcting mistakes.*—It may be necessary to fallow the land in order to clear it of stones, stumps and brush. But after the land is once thoroughly subdued, summer-fallowing is very rarely necessary if the land has been well handled. If the land has been plowed when too wet and thereby has become lumpy, if it has been allowed to become foul with weeds, or if it has lost heart by too continuous cropping with one kind of crop, summer-fallowing is a good means of bringing it back into condition. The better the farming, the less the necessity of summer-fallowing. In the old days, the poor tillage tools rendered fallowing more necessary than it is to-day.

Fallowing is tillage; and tillage liberates plant-food. Some of this plant-food may leach away and be lost, although the small rainfall of the summer months,—during which time fallowing is practiced,—makes this loss slight.

14. *The kind of tillage should vary with the soil, the time of year, the kind of crop.*—Too many farmers seem to think that tillage is tillage, no matter how it is performed. The same tool is used for clay or sand or muck, and for fitting the land for wheat or corn or apple trees. A harrow that is best for one field may be worst for the adjoining field. A man would not think of using a buggy for carrying grain to market, but he will use one tool for many kinds of work. The work is not only poorly done,

but it is not economical. It costs too much. Persons who will economize to the smallest degree in expenditures of money, may be very wasteful in expenditures of labor and muscle.

Persons are always asking if deep plowing is best. The question cannot be answered on general principles. Deep plowing may be best for one field and one crop, and shallow plowing best for another field and another crop. The same remarks will apply to fall-plowing and spring-plowing. One must first learn principles, or the why; then the practice, or the how, will come easy.

NOTE. The reader should have other sources of information than this Lesson. He may read our Bulletins 119, "Texture of the Soil;" 120, "The Moisture in the Soil;" 72, "The Cultivation of Orchards;" and the three bulletins on potato culture (Nos. 130, 140, 156). His library should also have King's "Soil" and Roberts' "Fertility of the Land."

This Reading-Lesson is sent free to all persons in New York State who are interested in agriculture. A supplement or quiz accompanies it, asking questions on the Lesson. Those who answer these questions will receive subsequent issues of Lessons. These Lessons are published by the College of Agriculture, Cornell University.

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CORNELL READING-COURSE FOR FARMERS

QUIZ ON READING-LESSON NO. 2.

DECEMBER, 1898.

BY L. H. BAILEY

These questions constitute a supplement to Reading-Lesson No. 2 (" Tillage and under-drainage: reason why"). Its purpose is to induce the reader to think carefully about what he reads. Answer the questions as best you can and return this sheet to us (2 cents postage). We want these answers in order that we may know what interest you are taking in the Reading-Course and how much good you are getting from it; and we want to help you when you do not understand the problems involved. We are after results, and do not care about the handwriting nor the grammar. These answers are for our own examination and are not to be made public. We should be glad of any comments on these lessons.

It is hoped that readers will form themselves into little clubs, to meet once or twice a month to discuss the problems raised by the lessons.

Those who answer the questions will receive future lessons.

1. What proportion of farmers in your neighborhood farm it like Mr. Black?

2. How is farming to be made to pay,—by getting higher prices or by cheapening cost of production?

3. Do you expect permanently higher prices for farm produce?

4. Do you set a certain yield before your mind when you are preparing for a crop? Or do you expect to be content with what comes?

5. An inch of rainfall weighs about 113 tons to the acre. About 300 tons of water is required to produce one ton of dry matter. Do you have rainfall enough in June, July and August to maintain a heavy crop of Indian corn or cabbage?

6. Does surface tillage make soil moist, or keep it moist?

7. Why does deep fall-plowing make soils "warm" or "early" in spring?

8. What proportion of farmers in your vicinity practice under-drainage?

9. How many of the farms need under-drainage?

10. How deep and how far apart would you lay under-drains?

11. Do the farmers of your neighborhood have enough different kinds of tools to enable them to till their land cheaply and efficiently?

12. How many different kinds of tillage tools should a man have to farm it properly, if he has 100 acres devoted to general farming, of which half is clay and half sandy soil?

13. How often would you till a field of corn or potatoes?

14. Why do you till your corn or potatoes? Are weeds the leading problem in your mind?

Name ....

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CORNELL READING-COURSE FOR FARMERS.

READING-LESSON NO. 3.

JANUARY, 1899.

BY G. W. CAVANAUGH.

Fertility of the Soil: What it is.

1. *To be fertile, a soil must contain plant-food.*—All plants during growth absorb certain substances from the soil. Those substances which are essential for the best growth and development of the plant are called plant-foods. These are iron, lime, potash, sulfur, silica, nitrogen, phosphoric acid, and six or seven more.

2. *The different plant-foods are equally essential.*—A plant must have each and every one of the different plant-foods. Each is essential to aid in some particular function, and no one can be substituted for another. If a soil were to contain all the other plant-foods and be lacking in phosphoric acid it could not be a fertile soil. It could not grow plants because phosphoric acid is necessary in the development of a plant, and no other substance is known that will take its place. The same remarks might be made respecting iron, lime, silicon, or the others.

3. *The different plant-foods are widely distributed in nature.*—A soil on which are growing only mulleins, moss or daisies, is usually not considered a fertile soil; and yet the fact that these plants grow shows that the soil contains the different elements of plant-food, at least to some extent. In such a case, the relative infertility is as likely to be due to the texture of the soil, or to its lack of moisture-holding capacity, as to a deficiency of mineral plant-food. A soil which is practically worn out for onions, may still grow rye or smartweed. See Lesson 1.

4. *The element of which there is relatively the least, determines the productive power of the soil (so far as plant-food is concerned).*—It may be that some one element is present only to a limited extent, in which case it will measure the producing power of the

soil. For if all the plant-foods are equally essential, it is evident that if in any soil there should be enough of all but one to produce 40 bushels of wheat per acre, yet of that one enough to supply only 15 bushels, then 15 bushels would be the largest crop possible. Hence it may be that the soil which grows sorrel and daisies has sufficient potash, phosphoric acid and other mineral plant-foods to produce a good yield of grasses, but it may be lacking in nitrogen, or may not have available moisture.

5. *Plants require that plant-food be available.*—Not every soil that contains an abundance of the different plant-foods is a fertile soil. The plant-food must be in such condition that the plant can use it. Gravel-stones might contain all the necessary mineral constituents, and muck has nitrogen ; yet a mixture of muck and gravel-stones would not be a fertile soil. Let the stones, through weathering, crumble and decay and become intimately mixed with the material of the muck and soil, considerable available plant-food might be made. For plant-food to be available, it must be in a condition to be dissolved by the soil water. Roots absorb the soil water and obtain their food by using that which is in solution. They never take their food in solid particles or chunks.

6. *The soil water can dissolve only that part of the soil with which it comes in contact.*—It comes in contact only with the outside of the ultimate particles of soil, and, obviously, the more numerous the particles the greater chance there is for the plant-food contained in these particles to be dissolved. It is in this light that we are to look upon tillage as making plant-food available by improving the texture of the soil.

7. *The proportions of the different plant-foods in the soil are variable.*—Nature has supplied a superabundance of most of the essential plant-foods ; but often some of them are either lacking or are in an unavailable condition from which the plant finds great difficulty in extracting them. Of the fourteen elements of plant-food that are essential to plants, only four, and more often three, are in this condition. These are nitrogen, phosphoric acid, potash and lime.

The term plant-food as ordinarily used by farmers includes the first three of these substances only ; not that they are any more

essential to plant growth than are the other substances, but because of the deficiency of them in many soils and their corresponding commercial importance.

8. *Phosphoric acid (P_2O_5) is one of the prime essentials.*—Every farmer, whether he has used phosphates or not, has seen phosphoric acid. When a match is ignited the little curl of white smoke which first appears is pure phosphoric acid, P_2O_5. The kind of match for this purpose is the old fashioned one known as a sulfur match, easily recognized by the blue, flickering flame and the odor of burning sulfur. The kind known as crack or parlor matches do not show phosphoric acid.

Showing what passes off when a blue-headea match is first ignited.

In the blue-black or red tip of this match there is a small amount of the substance called phosphorus. For convenience and shortness this name is represented by the letter P. When this phosphorus is warmed up by friction it burns, and in burning it unites with oxygen from the air. Oxygen is represented by O. The figures 2 and 5 in this symbol P_2O_5, mean that 2 parts of P are united with 5 parts of O. The result is the white substance of the smoke, or pure phosphoric acid, such as is sold in phosphates.

9. *Farmers buy phosphoric acid in combinations with lime.*—Phosphoric acid does not exist in the soil in the free state, that is, not as one sees it on igniting a match. It readily unites with lime to form phosphates of lime. The chemical name of lime is calcium oxide (CaO) and the phosphates of lime are called calcium phosphates. Water is H_2O.

Lime and phosphoric acid unite in three different proportions :

I. One part phosphoric acid and 3 of lime, ... $\left.\begin{array}{l}CaO\\CaO\\CaO\end{array}\right\} P_2O_5$

II. One part phosphoric acid and 2 of lime, ... $\left.\begin{array}{l}H_2O\\CaO\\CaO\end{array}\right\} P_2O_5$

III. One part phosphoric acid and 1 of lime, ... $\left.\begin{array}{l}H_2O\\H_2O\\CaO\end{array}\right\} P_2O_5$

These are called respectively tri-calcic phosphate, di-calcic phosphate and mono-calcic phosphate.

It is in the form of these calcium or lime combinations that plants obtain their phosphoric acid. These three substances vary in the way in which they dissolve in water, and hence are not equally available as plant-food.

The mono-calcic phosphate dissolves in water as does sugar or salt and consequently its phosphoric acid is directly available. The di-calcic phosphate does not dissolve in water, but becomes soluble in the soil water, which contains carbonic acid gas in solution. The di-calcic phosphate is therefore available phosphoric acid. The mono-calcic phosphate tends to pass into the di-calcic condition in the soil; when so changed it is said to be "reverted."

The total available phosphoric acid in a fertilizer is that which it contains in the forms of mono- and di-calcic phosphates. The tri-calcic phosphate is soluble neither in water nor in soil water, and is known as the insoluble phosphoric acid.

10. *These phosphates are made mostly from bone (either recent or fossil.)*—Bones are the chief source of phosphoric acid. The phosphate rock deposits found in the South are from ancient bone deposits. In bones the phosphoric acid is insoluble: that is, it is there as tri-calcic phosphate. To make it available, the bones are treated with sulfuric acid (oil of vitrol) and water. In the action which takes place, the sulfuric acid takes from the phosphoric acid one or two parts of its lime and puts water (H_2O) in their places. The lime which is taken away by the sulfuric acid, unites with the sulfuric acid and forms sulfate of lime (gypsum or land plaster). Gypsum is always a constituent of a fertilizer containing available (or treated) phosphoric acid.

11. *Potash (K_2O) is also an essential fertilizer material.*—Most soils contain more potash than phosphoric acid. The potash in soils is mostly locked up in compounds known as silicates. Pure sand is silica. These silicates are insoluble in water, and hence the potash is not readily available. Perhaps it is well that nature locked up the potash in such a strong combination as a silicate, or it might have run out, as the nitrogen has from many soils.

12. *Potash is made available by tillage, and the decay of humus.*—

Certain other substances also tend to render potash available as lime, salt and plaster.

13. *If potash is to be applied to the soil, it may be had in three forms: as the sulfate of potash, muriate of potash, and carbonate of potash. The last occurs in wood ashes.*

Potash is represented by two letters, K and O, to indicate that it, like phosphoric acid, is composed of two elements, i. e., potassium K* and oxygen O, and the figure 2 in K_2O denotes that it contains two parts of K and one of O.

When potash is combined with sulfuric acid, or oil of vitrol, it forms sulfate of potash.

When combined with muriatic acid it forms muriate of potash. In wood ashes the potash is united with carbonic acid to make the carbonate of potash. Muriate of potash, KCl, comes from Germany, where deposits are found, about like our own deposits of common salt.

The sulfate is made from the muriate, by substituting sulfuric acid in the place of muriatic acid.

14. *Nitrogen is an essential fertilizing element.*—Nitrogen is the most expensive and consequently the most important, commercially, of the plant-foods. It exists in that part of the soil composed of organic material, i. e., that arising from the decay of vegetable or animal matter.

There is no nitrogen in common rocks. By burning from a handful of soil all the organic part, the nitrogen will be lost. The nitrogen originally all came from the atmosphere. Four-fifths of the air is nitrogen. In the pure state it is a gas, but in the soil it is a constituent of the organic materials.

15. *Nitrogen must be in combinations to be available.*—The nitrogen that exists as a constituent of any organic material is called organic nitrogen. This combination is found in manures, green-crops and in fact in all vegetable material; also in dried blood and tankage.

Nitrogen is a constituent also of ammonia or hartshorn (NH_3). By weight, fourteen of every seventeen parts of ammonia is nitrogen. Hence when the odor of ammonia escaping from manure

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*This letter is used to denote potassium to avoid confusion with phosphorus, and because K is the first letter of kalium, Latin for potassium.

piles is noticed, there is a loss of nitrogen. Nitrogen in ammonia is called ammoniacal nitrogen.

Nitric acid (HNO_3), or aqua fortis of the drug stores, as its name indicates is also a compound of nitrogen. When nitric acid unites with soda, potash or lime, substances known as nitrates are formed. The mineral takes the place of the hydrogen (H). With soda (Na), nitric acid forms nitrate of soda, ($NaNo_3$.)

16. *Nitrogen is closely connected with growth and development, in distinction to stockiness or fruitfulness.*—Cereals that grow too much to stalk with immature seeds, usually have too much nitrogen and not enough P_2O_5 and K_2O. A yellow color, and short growth, suggest a deficiency of nitrogen or moisture, or both.

17. *Plants cannot use all forms of nitrogen in combination. They use only that existing as a nitrate.*—Most of the nitrogen that is supplied to the soil in manures and green-crops, is in the form of organic nitrogen, which is not directly available as plant-food.

However, in a soil in good tilth and having suitable moisture, the nitrogen in the organic material will be changed into nitric acid.

The nitric acid, uniting with the potash, soda or lime in the soil, forms nitrates. All nitrates are soluble in water, and thus available nitrogen is furnished to the roots.

This change of the nitrogen into nitric acid and nitrates is effected by germs or microbes, and is called nitrification.

18. *Barn manures supply plant-food.*—The amounts of nitrogen, phosphoric acid and potash in manures are small, not enough in fact to account for all the beneficial effects obtained. Manures are particularly useful in supplying organic matter, which improves the condition of soils by increasing the moisture-holding power. The more organic matter soils contain, within ordinary limits, the more moisture they can hold. Compare sands with mucks. Consult Lessons 1 and 2.

19. *Amendments are sometimes very needful.*—Certain substances produce beneficial effects and yet supply little or none of the necessary plant-foods. Lime, salt and plaster may be cited. Crops that require potash are often helped by these materials. They contain no potash and yet they furnish it to the plants by helping to unlock it from the insoluble silicates. When the oil is

low and the wick short, the lamp may be made to continue burning by adding water to raise the oil within reach of the wick.

Substances acting in this way are not fertilizers in the strict sense of that term. They are amendments.

20. *Acid or sour soils are usually unproductive.*—They may be made neutral or "sweetened" by means of lime or ashes. The marked benefits sometimes secured by the use of ashes are owing more to the sweetening of the soil than to the addition of plant-food.

The farmer may determine if his soil is sour by testing it with blue litmus paper. Buy five cents' worth of this paper at the drug store. Press it firmly against a fresh, moist surface of soil. If the paper turns red, the soil is acid; and the quicker and more completely the color changes the sourer the soil. The test may also be made by inserting the blue litmus paper in water with which the soil is shaken up. A lump of frozen soil may be thawed out in water, and the test applied. An alkali (like lye or lime) will change the reddened litmus back to blue.

NOTE.—For further information on fertilizers and plant-food problems, read Voorhees' "Fertilizers." (The Macmillan Co.)

Lesson No. 4 will tell how the plant obtains its food from the soil. Let the reader now place a few radish seeds between folds of heavy flannel, and keep them warm and moist. They will then be ready to show the root-hairs when Lesson No. 4 arrives.

This Reading-Lesson is sent free to all persons in New York State who are interested in agriculture. A supplement or quiz accompanies it, asking questions on the Lesson. Those who answer these questions will receive subsequent issues of Lessons.

The Lessons thus far issued are:

1. *The soil: what it is.*
2. *Tillage and underdrainage: reasons why.*
3. *Fertility of the soil: what it is.*

Two more will be issued this winter:

4. *How plants get their food from the soil.*
5. *How plants get their food from the air.*

These Lessons are published by the College of Agriculture, Cornell University, under the auspices of the Agricultural Extension (or Nixon) fund.

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Deputy Chief.

CORNELL READING-COURSE FOR FARMERS

QUIZ ON READING-LESSON No. 3

JANUARY, 1899

BY L. H. BAILEY.

These questions constitute a supplement to Reading Lesson No. 3 ("Fertility of the Soil: what it is"). Its purpose is to induce the reader to think carefully about what he reads. Answer the questions as best you can and return this sheet to us (2 cents postage). We want these answers in order that we may know what interest you are taking in the Reading-Course and how much good you are getting from it; and we want to help you when you do not understand the problems involved. We are after results, and do not care about the handwriting nor the grammar. These answers are for our own examination and are not to be made public. We should be glad of any comments on these lessons. Those who answer the questions will receive future lessons.

You may not be able at first to see the point to some of the questions. It is the purpose of these questions to set you to thinking about the problem in hand, rather than to find out all that you know about the subject.

When the reading season is over, we hope to send you a Lesson containing correct answers to all the questions in the five Lessons.

Before spring opens, we propose to suggest how you can find out what fertilizer you need to apply to your land

Do plants obtain all their food from the soil?

What do you mean when you say that soil is exhausted,—that it has no more plant-food in it, ormerely that it fails to produce crops?

May a soil fail to produce crops and yet not be exhausted of plant-food?

If there are 13 plant-foods which are positively essential, why do we speak of only 3 of them as plant-food,—of nitrogen, potash, phosphoric acid?

Do you know if there is any difference between phosphorus and phosphoric acid? Write the chemical symbol for each.

Is there any difference between potassium and potash? Write chemical symbols for each.

Write the chemical symbols for calcium and lime.

Where do phosphorus, potassium and calcium come from,—from the ground or the air? Are they gases or solids?

Where does the oxygen come from, with which they are combined?

Do you know if phosphorus, potassium and calcium exist in nature in their pure state?

Does oxygen exist anywhere in a pure or uncombined state?

Of what is water composed? Write its chemical formula.

Of what is ammonia composed? Is it a gas or liquid? Can you buy pure ammonia at the drug store?

Does the plant feed on ammonia directly?

What is the composition of a nitrate? Write the formula for nitrate of potash and nitrate of lime.

In what kind of materials does nitrogen occur? Name some common things which you think contain nitrogen.

Is nitrogen a solid or a gas?

Are nitrates of potash and soda solids, liquids or gases?

Are nitrates soluble? Is there danger of their being lost from the soil?

What is an amendment?

Is the soil in your garden sour? Try it.

In what materials can you buy phosphoric acid for fertilizer purposes?

In what can you buy potash?

In what can you buy nitrogen?

Are there any home fertilizers, or common farm materials (aside from barn manure), in which you can get these three elements?

CORNELL READING-COURSE
FOR FARMERS.

READING-LESSON
NO. 4.
FEBRUARY, 1899.

BY B. M. DUGGAR.

How the Plant Gets Its Food from the Soil.

1. *Roots feed obscurely.*—The poultry yard is a proper place to observe how the chicken takes its food and drink, but garden observations alone do not furnish us equal evidence concerning the garden plant. Every one knows that the plant takes water and soluble substances from the soil by certain root structures; but the facts about the interesting activities of these roots too often remain a secret of the soil. These activities may seem obscure, but let us handle the plant, make a few simple experiments, and see what the study yields. In this study we are concerned with the one question of how the plant gets this water and other food materials from the soil, disregarding entirely the various kinds of substances that may be used as foods.

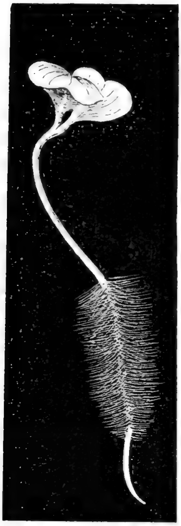
1. *Radish.*

2. *There are roots and there are rootlets.*—In Figure 1 we have a radish plant ready for the table. It has developed no seeds, but it has stored up food; and for present purposes we may consider it a mature plant. To begin with, observe how its root system is constructed.

The plant has been pulled out of the soil in which it was growing. The large fleshy root terminates in a common-sized root (*a*) to which little rootlets (*b*) are attached. Then there are little rootlets (b^1) attached to the fleshy root at various places near the base; and this we expected, knowing that the fleshy root is nothing but the enlarged tap-root. But the rootlets which we so readily see are only intermediary, and

there are numerous yet smaller structures which we do not see at all when we handle the plant so roughly.

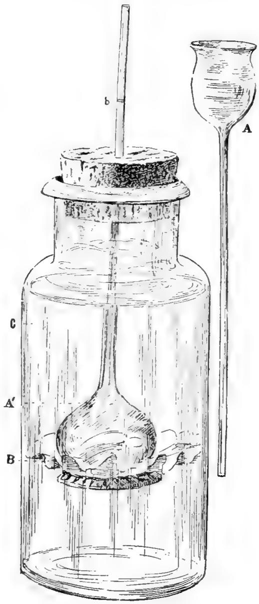
3. *The rootlets are clothed with hairs (root-hairs) which are very delicate structures.*—Next we will carefully germinate some radish seed so that no delicate parts of the root will be injured. For this purpose we simply sow a few seed in packing-moss or in the folds of some black cloth, being careful to keep them moist. In a few days a seed has germinated, the root has grown an inch or two, and branched once or twice, perhaps. Lift the moss carefully, or open the folds of the cloth. Figure 2 shows what may be found. Now notice that at a distance of about a quarter of an inch from the tip, the root is covered with a delicate fringe of hairs. They are actually hairs, that is, root-hairs. Touch them and they collapse, they are so delicate. Dip one of the plants into water, and when removed the hairs are not to be seen. The water mats them together along the root and they are no longer evident. No wonder we cannot see root-hairs well when a plant is pulled out of the soil, be it done ever so carefully! These delicate root-hairs clothe the young rootlets, and we can hardly estimate what a great amount of soil is thus brought into actual contact with the plant. The value of this contact we shall soon see. Root-hairs are not young roots.



2. *Root-hairs of radish.*

4. *The rootlet and the root-hair differ.*—The rootlet is fleshy in its way,—a solid compact structure. The root-hair is a tubular plant cell, that is, a delicate little tube, within the cell wall of which is contained living matter (protoplasm); and the lining membrane of this wall permits water and substances in solution to pass in by a very interesting physical process. Being long and tube-like, these root-hairs are especially adapted for taking in the largest quantity of solutions; and they are, in fact, the principal means by which plant-food is absorbed from the soil, although the surfaces of the rootlets themselves do their part. Water-plants do not need an abundant system of root-hairs, and such plants depend largely upon their rootlets.

5. *A salt solution separated by a membrane from water absorbs some of the water and increases it own volume.*—To understand better how the root-hairs absorb their water, we will study that physical process already mentioned. First dissolve one ounce of saltpetre, which we may use as a fertilizer solution, in one pint of water, calling this solution I. For use in some experiments later on, also dissolve a piece of saltpetre not larger than a peach pit (about $\frac{1}{7}$ oz.) in about one gallon of water, calling the latter solution II. Now fill the tube A in figure 3 almost full of the strong solution I., and tie a piece of animal membrane (hog's bladder is excellent for this purpose) over the large mouth. A small funnel, with a long stem, may be used if one cannot obtain a tube like A. Then sink the tube, bladder part downward, into a large bottle of water until the level of liquid in the tube stands at the same height as that in the bottle C. The tube may be readily secured in this position by passing it through a hole in the cork of the bottle. In a short time, we notice that the liquid in A^1 begins to rise, and in an hour or so it stands as at b, say. This is an important result: see that we do not forget it, for it explains many things. The facts are that the liquids tend to diffuse, but the strong solution in A^1 cannot pass through the bladder B as rapidly as the water outside can pass into A^1. Then there is evidently absorption of water and pressure in A^1 which forces the liquid up higher than in C. The liquid in A^1 would continue to stand higher than in C while this absorption goes on. Thus we know that a strong fertilizer solution, or any solution denser than water, separated from water by membrane, will absorb water. This is an instance of that which physicists have named osmosis. It is osmotic action.



3. *How to illustrate osmosis.*

6. *The cell sap of the root-hair absorbs water from the soil by osmotic action.*—The experiment above detailed enables us to

understand how the countless little root-hairs act,—each one like the tube A', if only the whole surface of the tube A^1 were a bladder membrane, or something acting similiarly ! The soil water does not contain much of the land's fertility ; that is, it is a very weak solution. The active little root-hair, on the other hand, is always filled with cell sap, a more concentrated solution ; hence soil water must come in, and along with it come also small quantities of dissolved fertilizers.

7. *The plant absorbs fertilizer solutions as long as they are used for the growth of the plant.*—The fertilizers (salts) which are dissolved in the soil water also diffuse themselves through the membrane of the root-hairs, each ingredient tending independently to become as abundant inside the root-hair as outside in the soil water. Now once inside the root-hair, these absorbed fertilizer solutions pass on to root and stem and leaf to be utilized in growth. As long as they are used up, however, more must come into the root-hairs, in order to restore the equilibrium. Thus those substances which are needed must come in as long as the land can furnish them in soluble form.

8. *Fleshy pieces of root or stem will absorb water from weak solutions and become rigid ; in strong solutions such fleshy parts will give up their water and become flexible.*—We have illustrated absorption by an artificial arrangement because the root-hairs are so small that they cannot be seen readily. But all parts of the root, even the fleshy part, can absorb some water ; and to experiment further with this principle of absorption, we cut several slices of potato tuber about one-eighth of an inch in thickness, and let them lie in the air half an hour. Put a few of these slices into some of the strong fertilizer solution I., such as was used in A^1, Fig. 3. Put other similar pieces into some of the very weak solution II. In about half an hour or more we find that those pieces in the weak solution are very rigid or stiff (turgid). They will not bend readily when held lengthwise between the fingers. Compare these slices with those in the strong solution, where they are very flexible (flaccid). This bending is evidently due to the fact that those in the strong brine have actually lost some of their water. So the potato tuber could take in soil water containing a small amount of food ; but put in

too much such food material and the potato would actually lose some of the water which it held.

The experiments which have been made not only demonstrate how the roots absorb water containing plant-food, but they emphasize the fact that the outside solution must be very dilute in order to be absorbed at all. The root-hairs, then, absorb water which has dissolved only a small amount of plant-food from the richness of the soil, and not such rich solutions as the sap of the plant itself.

9. *The plant may be wilted, and even killed, by attempting to feed it fertilizer solutions which are too strong.*—More carefully to test this matter relating to the use of strong solutions, we may make a very simple experiment. Secure a young radish plant (or almost any seedling with several leaves) and insert the roots into a small bottle containing some of the saltpetre solution I. In another bottle we put a similar plant with some of the weak solution II. Support the plant in the mouth of the bottle with cotton batting. After standing for a few hours or less it will be noticed that the leaves of the plant in the strong fertilizer solution begin to wilt, as in Fig. 4. The plant in the weak fertilizer solution, Fig. 5, is perfectly rigid and normal. This further indicates that the growing plant is so constituted as to be able to make use of very dilute solutions only. If we attempted to feed it strong fertilizer solutions, these strong solutions instead of being absorbed by the plant take water from the latter, causing the plant to wilt. In fact, saltpetre seems to be most available for plant-food when one ounce is dissolved in about seven or eight gallons of water.

4. *Killed by too much food.*

10. *The injurious effect of strong fertilizer solutions is known in practice.*—In every-day practice we are already familiar with the fact above demonstrated. Everyone recognizes the value of wood ashes as a fertilizer; but no one would dare water his valuable plants with lye, or sow his choice vegetable seeds on an

ash bank, however well it might be watered. If there is a potted plant at hand which is of no value, we might remove some of the soil, add considerable wood ashes, water well, and await the result. Try it; or give it a lump of nitrate of soda.

11. *The soil water is a very dilute solution.*—In Reading-Lesson No. 2 the different kinds of water in the soil were mentioned; and it was stated that the water which is valuable to the plant is not the free water, but the thin film of moisture which adheres to each little particle of soil. Any one who has drunk water from a tile drain knows that at least the free water which has soaked from the soil must contain relatively very little plant-food, else our delicate taste would detect it. Perhaps the film moisture contains a little more plant-food than the free water, but the quantity of substances in solution is generally extremely minute, so that the soil water is readily absorbed by the plant.

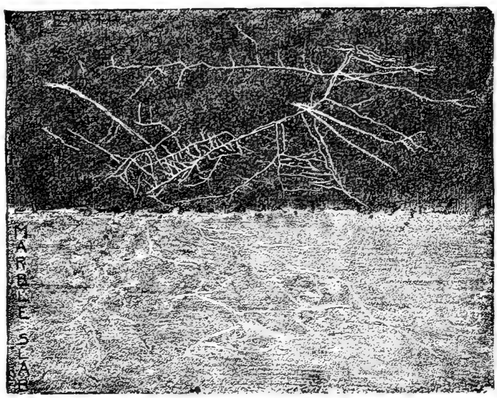
5. *Thriving in a weak solution.*

12. *Root absorption may continue in a soil that seems to be dry.*—Not only is free water unnecessary for ordinary land plants, but the amount of film moisture present does not need to be very great. It is remarkable how dry a soil may feel to the fingers, and yet afford sufficient water to maintain the plant. This may be readily studied with a potted plant, or observed in the field.

13. *The roots need air.*—Corn on a piece of land which has been flooded by the heavy rains looses its green color and turns yellow. Besides diluting plant-food, the water drives the air out of the soil, and this suffocation of the roots is very soon felt in the general health of the plant. The film moisture alone (hygroscopic water) is best to insure proper aëration. The value of tillage for aëration purposes has already been mentioned in Reading-Lesson No. 2. Water-plants and bog-plants have adapted themseleves to their particular conditions. They either get their air by special surface roots, or get it from the water.

14. *The root must be warm in order to perform its functions.*—Should the soil of fields or greenhouses be much colder than the air, we would find a very bad state of affairs for the plant. When in a warm atmosphere, or in a dry atmosphere, plants need to absorb much water from the soil, and the roots must be warm in order that the root-hairs may be so active as to supply the water as rapidly as it is needed. If the roots are chilled, then the plant will wilt. We may try this experimentally with two potted plants, as radish, coleus, tomato, etc. Put one pot in a dish of ice water, and the other in a dish of warm water, and keep them in a warm room. In a short time notice how stiff and vigorous is the one whose roots are warm. Perhaps the one whose roots are chilled is already beginning to show signs of wilting.

15. *Roots excrete substances which aid in dissolving plant-food from some soil compounds which are insoluble in water.*—Ordinarily there would be in solution in soil water only those substances which are soluble in the water alone. The plant is not only provided for absorbing what is already there in a soluble form, but it is also capable of rendering soluble small quantities of the insoluble substances present in the soil, and which may be needed for plant-food. The plant accomplishes this purpose by means of certain excretions from the roots. In other words, not only does the plant absorb dilute solutions, but it gives off through its root-hairs small quantities of acids.



6. *Root-prints in marble. The upper part represents the sawdust soil, turned back.*

These acids may even etch marble. Fig. 6, from Bailey's "Principles of Agriculture" illustrates this. "On a polished marble block, place a half inch of sawdust, in which plant seeds. After the plants have attained a few leaves, turn the mass of sawdust over and observe the prints of the roots on the marble." These prints will be very faint.

This Reading Lesson is sent free to all persons in New York State who are interested in agriculture. A supplement or quiz accompanies it, asking questions on the Lesson. Those who answer these questions will receive subsequent issues of Lessons.

The Lessons thus far issued are :

1. *The soil : what it is.*
2. *Tillage and underdrainage : reasons why.*
3. *Fertility of the soil : what it is.*
4. *How plants get their food from the soil.*

One more will be issued this winter:

5. *How plants get their food from the air.*

These Lessons are published by the College of Agriculture, Cornell University, under the auspices of the Argicultural Extension (or Nixon) fund.

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CORNELL READING-COURSE FOR FARMERS

QUIZ ON READING-LESSON NO. 4.

FEBRUARY, 1899.

By L. H. BAILEY.

These questions constitute supplement to Reading Lesson No. 4 ("How the plant gets its food from the soil"). Its purpose is to induce the reader to think carefully about what he reads. Answer the questions as best you can and return this sheet to us (2 cents postage). We want these answers in order that we may know what interest you are taking in the Reading-Course and how much good you are getting from it; and we want to help you when you do not understand the problems involved. We are after results, and do not care about the handwriting nor the grammar. These answers are for our own examination and will not be made public. We shall be glad of any comments on these lessons. Those who answer the questions will receive future lessons.

When Lesson No. 5 shall have been digested, we hope to send you a supplementary Lesson answering questions in all five Lessons, and also suggesting how you may find out what fertilizers your soil and crops need.

Do the root-hairs finally become roots, or do they stay on as the main root grows?

Are there root-hairs on old roots?

On what part of the roots are the root-hairs?

Where does the radish plant, which you grow in moss or between folds of cloth, get nourishment for making the root-hairs?

Why do particles of soil adhere to a young plant of wheat or cabbage when it is pulled up?

What do you understand by a solution?

Give an example of a substance which will dissolve in water, and one which will not.

May materials which are insoluble in rain water be soluble in soil water? Why? (Consult Less. 3.)

Does warming the water increase its power to make substances soluble?

Write a definition of osmosis. (Consult dictionary or some school book on physics or natural philosophy.)

Why does the soil water go into the root-hair?

Why does not the liquid in the root-hair flow out into the soil?

What would happen if the liquid in the root-hair and that in the surrounding soil were of equal density?

Must all food materials in the soil be in solution before the plant can use them?

Does the plant ever utilize materials which are insoluble in the soil water? How?

How is it that plants can live and grow in a soil which is dust dry?

Can your soil be so loose as to have too much air for the good of the plants?

Do you understand that you can smother the root as well as the top of the plant? How?

At what season do you suppose that corn roots absorb the most moisture?

At what season do you have the least rainfall?

If you knew that you would not have sufficient rainfall in August to maintain your potato crop, how would you plan to secure the moisture?

Name one way in which plants are injured by too strong dressings of potash or nitrogen.

If all the potash in your cornfield were to become suddenly available, what would happen?

How might you apply muriate of potash so that strawberry plants would be injured?

Would it be an easy matter to injure old apple trees by muriate of potash? Why?

If you put the fertilizer in the hill, will not the roots grow beyond and away from it, as the plant grows?

Name...

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CORNELL READING-COURSE FOR FARMERS.

READING-LESSON
No. 5.
MARCH, 1899.

BY B. M. DUGGAR.

How the Plant Gets its Food from the Air.

1. *Charcoal is largely carbon, and carbon enters abundantly into the composition of all plants.*—Half or more of the bulk of the tree, aside from water and the elements of water, is carbon. When the tree is charred (or incompletely burned), the carbon remains in the form of charcoal. The ordinary cultivated plant has but two sources from which to obtain food—the air and the soil. In a corn plant of the roasting-ear stage, the water forms about eighty per cent of the structure. There is, then, about twenty per cent of dry matter remaining after the water has been driven off. In order to form some idea of what portion of the plant structure comes from the air, note that when such a corn plant is burned in air, the amount of ash remaining is about one per cent of the total substance. This ash consists of practically all of the fertilizers which we found in Reading-Lesson No. 3 to come from the soil, with the exception of the nitrogen. The entire nitrogenous product forms about two per cent of the total green substance. It was driven off by the burning. Next note what happens when a plant is burned without free access of air, or smothered, as in a charcoal pit. The mass of charcoal resulting is almost as large as the body of the plant. Carbon is the element now present which was not present in the ash.

Charcoal is almost pure carbon, the ash present being so small in proportion to the large amount of carbon that we look upon the ash as an impurity. The fact is that the carbon and the elements of water (hydrogen and oxygen) make up more than ninety per cent. of the dry matter of the corn plant.

The percentage of dry matter which comes from the soil may

NOTE.—In this treatment of the relation of the plant to the air, only the higher or agricultural plants are referred to.

seem absurdly small; for we are constantly engaged in supplying fertilizers to the soil, and never seem to trouble ourselves about this important substance carbon. It was an interesting fact that the carbon went off as a gas when the plant was burned in air. The carbon did not go off alone, but it went off in connection with oxygen, and in a form called carbon dioxid gas, CO_2.

2. *The air contains a small percentage of carbon dioxid, but oxygen and nitrogen are the abundant elements.*—The green plant must get its carbon from the air. In other words, much of the solid matter of the plant comes from one of the gases in the air. Carbon dioxid is only about four-tenths of one per cent in the air. It would, however, be very disastrous to animal life if this percentage were much increased.

Carbon dioxid is often called "foul-gas." It may accumulate in old wells, and an experienced person will not descend into such wells until they have been tested with a torch. If the air in the well will not support combustion, that is, if the torch is extinguished, it usually means that no wise man would care to breathe such air. The air of a closed school-room often contains far too much of this gas along with little particles of solid carbon.

3. *The carbon dioxid of the air readily diffuses into the leaves and other green parts of the plant.*—The leaf is delicate in texture, and often the air can enter directly into the leaf tissues. There are, however, special inlets provided for the diffusion of gases into the leaves and other green parts. These inlets consist of numerous pores (stomates, or stomata) which are especially abundant on the under surfaces of the leaves. The apple leaf contains about one hundred thousand of these pores to each square inch of the under surface. Through these stomates the outside air enters into the air spaces of the plant; and finally into the little cells containing the living matter.

4. *The green color of leaves is due to a substance called chlorophyll.*—Purchase at the drug store about a gill of the poison, wood alcohol. Secure a leaf of geranium, or of any convenient plant which has been exposed to sunlight for a few hours, and put it in a white cup with sufficient alcohol to cover the leaf. Place the cup on the stove where it is not hot enough for the alcohol to take fire. After a time the coloring matter is all dis-

solved by the alcohol, which has become an intense green. This green coloring matter is dissolved chlorophyll. Save this leaf for a future experiment.

In the living plant this chlorophyll or leaf-green is scattered throughout the green tissues in little oval bodies, and these bodies are most abundant near the upper surface of the leaf, where they can secure the greatest amount of light. Without this green coloring matter, there would be no reason for the large flat surfaces which the leaves possess, and no reason for the fact that the leaves are borne most abundantly out at the ends of branches where the light is most available.

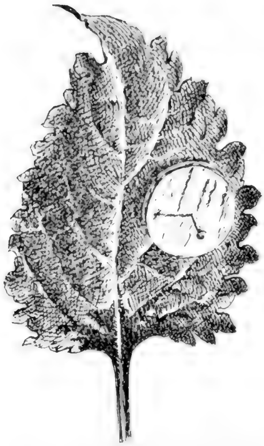
5. *Plants grown in darkness are yellow and slender, and do not reach maturity.*—Compare the potato sprouts which have grown from a tuber lying in the dark cellar with those which have grown normally in the bright light. The shoots from the cellar are yellow and slender. They have reached out for that which they cannot find; and when the carbon which is stored in the tuber is exhausted, these shoots will have lived useless lives.

A plant which has been grown in darkness from the seed will complete its life even in its infancy, although for a time the little seedling will grow very tall and slender. Light makes possible the production of this green color; and it is evident that the light and this green color together have to do with the utilization of the carbon dioxid of the air.

6. *Carbon dioxid is absorbed by the leaf during sunlight, and oxygen is given off.*—Some proverbs are founded on facts. It is true that plants purify the air during the day. Under the influence of sunlight and the green color of the foliage, the carbon dioxid which enters into the leaf is absorbed by the living parts, and with this absorption of carbon dioxid there is given off oxygen, which is necessary at all times to sustain life.

Very careful experiments have shown that carbon dioxid is absorbed and that oxygen is given off by all green surfaces during the hours of sunlight. How this carbon dioxid which is thus absorbed may be used as food is a question of much interest.

7. *Chlorophyll absorbs the heat of the sun's rays, and the energy thus obtained is used by the living matter in uniting*



1. *Excluding light from a part of a leaf.*

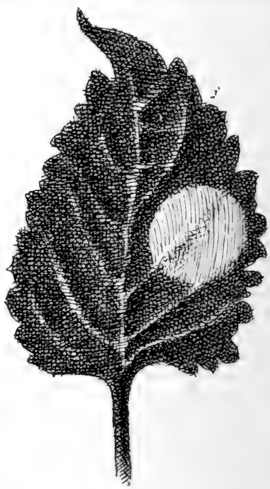
the carbon dioxid absorbed from the air with some of the water brought up by the roots. The process by which these compounds are united is a complex one, but the ultimate result is starch.—The snow on black soil melts quickly because the black absorbs the heat of the sun. The green chlorophyll of the leaf absorbs certain heat rays, and this heat affords a peculiar vital energy which enables the living matter of the leaf to unite carbon dioxid and water. No one knows all the details of this process; and our first definite knowledge of the product begins when starch is deposited in the leaves.

Starch is composed of carbon, hydrogen and oxygen ($C_6H_{10}O_5$). The sugars and the woody substances are very similar to it in composition. All these substances are called carbohydrates.

In making this starch from the carbon and oxygen of carbon dioxid and from the hydrogen and oxygen of the water, there is a surplus of oxygen. It is this oxygen which is given off into the air.

The process of using the carbon dixoid of the air is known as carbon assimilation.

8. *Starch is present in the green leaves of plants which have been exposed to sunlight; but in the dark no starch can be formed from carbon dioxid.*—Procure at the drug store an ounce or so of tincture of iodine. Pour a drop or two of this iodine on some ordinary starch paste or a slice of potato. The starch is colored blue or purplish-brown. This reaction is characteristic of starch. Now pour some of the iodine on the leaf from which we dissolved the chlorophyll in a previous experiment (page 3). Note that the leaf is colored purplish-brown throughout. The leaf contains starch.



2. *The effect on the leaf.*

Secure a leaf from a plant which has been in the darkness for about two days. Dissolve the chlorophyll as before, and attempt to stain this leaf with iodine. No purplish-brown color is produced. A leaf kept in darkness contains no starch.

This demonstration may be made much more instructive in another way. Secure a plant which has been kept in darkness for twenty-four hours or more. Split a small cork and pin the two halves on opposite sides of one of the leaves, as shown in Fig. 1. Place the plant in the sunlight again. After a morning of bright sunshine dissolve the chlorophyll in this leaf with alcohol, as before; then stain the leaf with the iodine. Notice that the leaf is stained deeply in all parts except in that part over which the cork was placed, as in Fig. 2. There is no starch in this area. These experiments also make it evident that the starch manufactured in the leaf may be entirely removed during darkness.

9. *Plants or parts of plants which have developed no chlorophyll can form no starch.*—Secure a variegated leaf of coleus, ribbon grass, geranium, or of any plant showing both white and green areas. On a day of bright sunshine test one of these leaves by the alcohol and iodine method for the presence of starch. Observe that the parts devoid of green color have formed no starch. However, after starch has once been formed in the leaves, it may then be changed and removed to be again formed as starch in other parts of the living tissues.

10. *Starch is in the form of insoluble granules. Whenever the material is carried from one part of the plant to another for purposes of growth or storage, it is changed to sugar before it can be transported.* When this starchy material is transferred from place to place, it is made soluble, changed into sugar, by the action of a ferment. This is a process of digestion. It is much like the change of starchy foods to sugary foods by the saliva of the mouth.

After being changed to the soluble form, this material is ready to be used in growth, either in the leaf, in the stem, or in the roots. With other more complex products it is then distributed throughout all of the growing parts of the plant; and when passing down to the root it passes more readily through the inner bark, in plants which have a definite bark. This gradual downward diffusion of materials suitable for growth through the

inner bark is the process referred to when the descent of sap is mentioned.

11. *The food from the air and the food from the soil unite in the living tissues.*—The sap constantly passing upward from the roots during the growing season is made up largely of the soil water along with the salts which have been absorbed in dilute solutions. This upward-moving sap is conducted largely by certain tubular cells of the young wood or of the woody bundles. These cells are never continuous tubes from root to leaf; but the water passes readily from one cell to another in its upward course.

The upward sap gradually passes to the growing parts, and everywhere in the living tissues it meets the liquid product returning from the leafy parts. Under the influence of the living matter of the plant, this product from the leaves first selects the nitrogen. A substance more complex than sugar is then formed, and gradually compounds are formed which contain sulfur, phosphorous, potassium and other elements, until finally living protoplasm is manufactured. Protoplasm is the living matter in plants. It is in the cells, and is usually semi-fluid.

12. *Starch and other products may be stored up during one growing period to be used during the next season.*—Although a plant strives to make a full amount of growth each season, it must also provide itself for developing a new crop of leaves and of fruit the next year, if it is to live more than a single season. It must also provide for its offspring. Tubers (white potato), stems (cacti), and roots (sweet potato) generally serve as storage organs for food. Thick, fleshy, leaves, as in the century plant, which live during many seasons, may also serve as storage organs.

The peach tree blossoms and sets its fruit, usually, before the leaves are open. In fact the food stored up one season has a most important influence in determining the crop of the next year. Bearing this in mind, one appreciates the value of keeping the leaves free from fungous and insect injuries throughout the growing season.

13. *Plants need oxygen for respiration, just as animals do.*—So far we have referred especially to the carbon dioxid of the air. To most plants the nitrogen of the air is inert, and only serves to dilute the other elements; but the oxygen is very nec-

essary for all life. We know that all animals need this oxygen in order to breathe, or respire. In fact they have become accustomed to it in just the proportions found in the air ; and this is now best for them.

When animals breathe the air once, they make it foul, because they use some of the oxygen and give off more carbon dioxid. Likewise, all parts of the plant must have a constant supply of oxygen. Roots need it, and this has already been emphasized in Reading-Lesson 4.

The oxygen passes into the air spaces and into the living protoplasm, performing a function of purification, as in animals. It is interesting to note that the air spaces in the leaf are equal in bulk to the tissues themselves. As a result of the use of this oxygen alone at night, plants give off carbon dioxid just as animals do. Plants respire ; but since they are stationary, and more or less inactive, they do not need so much oxygen as animals ; and they do not give off so much carbon dioxid.

During the day plants use so much more of the foul-gas carbon dioxid than of oxygen that plants are said to purify the air. The carbon dioxid which plants give off at night is very slight in comparison with that given off by animals ; so that a few plants in a sleeping room need not disturb one more than a family of mice, perhaps. Plants usually grow most rapidly in darkness.

14. *The plant has an important connection with the water vapor of the air.*—In addition to obtaining much of its food supply from the air, the plant has an important relation to the humidity of the atmosphere. Cut off a succulent shoot of any plant, stick the end of it through a hole in a cork and stand it in a small bottle of water. Invert over this bottle a large-mouthed bottle (as a fruit-jar), and notice that a mist soon accumulates on the inside of the glass. In time drops of water form. The plant gives off water from its leaves and from other succulent parts.

It has been mentioned that the plant takes its food from the soil in very dilute solutions. Then much more water is absorbed by the roots than is used in growth ; and it is this surplus water which is given off from the leaves into the atmosphere by an evaporation process known as transpiration.

Transpiration takes place more abundantly from the under sur-

faces of leaves, and through the pores or stomates. It has been found that a sun-flower plant of the height of a man during an active period of growth gives off more than a quart of water per day. A large oak tree may transpire one hundred and fifty gallons per day during the summer. For every ounce of dry matter produced, it is estimated that from fifteen to twenty-five pounds of water must pass through the plant.

15. *When the roots fail to supply to the plant sufficient water to equalize that transpired by the leaves, the plant wilts.*—Transpiration from the leaves and delicate shoots is increased by all of the conditions which would increase evaporation; such as higher temperature, dry air, wind, etc.

The stomates are so constructed that they open and close with the varying conditions of the atmosphere, attempting to regulate transpiration. However, during periods of drought, or of very hot weather, and especially during a hot wind, the closing of these stomates cannot sufficiently prevent evaporation. The roots may be very active, and yet fail to absorb sufficient moisture to equalize that given off by the leaves. As a consequence of this, the plant wilts. Any injury to the roots, or even chilling them, may cause the plant to wilt. On a hot, dry day note how the leaves of corn "roll" towards afternoon. Early the following morning note how fresh and vigorous the same leaves appear.

The wilting of a plant is due to the loss of water from the cells. The cell walls are soft, and collapse. A grain bag will not stand alone, but it will stand when filled with wheat. In the woody parts of the plant, the cell walls may be stiff enough to support themselves, even though the cell is empty.

CORNELL READING-COURSE
FOR FARMERS.

QUIZ ON
READING-LESSON
NO. 5.
MARCH, 1899.

By L. H. BAILEY.

These questions constitute a supplement to Reading Lesson No. 5 ("How the plant gets its food from the air"). Its purpose is to induce the reader to think carefully about what he reads. Answer the questions as best you can and return this sheet to us (2 cents postage). We want these answers in order that we may know what interest you are taking in the Reading-Course and how much good you are getting from it; and we want to help you when you do not understand the problems involved. We are after results, and do not care about the handwriting nor the grammar. These answers are for our own examination and will not be made public. We shall be glad of any comments on these lessons. This is the last regular Lesson for this season.

Next month we hope to send you a supplementary Lesson containing correct answers to all the questions in the five Lessons. It will also offer suggestions as to how to experiment to find out what fertilizers your soil needs. Some general remarks will be made respecting the results which have been attained in the Reading Course.

What proportion of its substance does the plant secure from the soil?

What one substance or compound is taken in most profusely by the plant?

How does the plant get its water,—through roots or leaves?

In what part of the plant does the water ascend,—through the young wood, or between the bark and wood?

Where does the plant get its carbon?

How does it take in its nitrogen,—by roots or leaves?

Where is the starch manufactured?

From what substances is the starch made?

Of what elements is starch composed?

Into what is the starch changed before is is transported?

What use is made of the material after it is transported?

Through what part of the plant does the starch-like material (or "elaborated sap") pass?

The root takes in water containing food: Can it use this food material directly in making root-growth? Why?

Why is starch stored in seeds and tubers?

Is starch stored in twigs in the fall?

Are the flowers of peaches, and other early-blooming plants, fed from food taken in at the root at the time, or from materials stored in the twig? (Think how the potatoes sprout in the bin.)

Will mulching the roots of a peach tree with straw when the ground is frozen delay the blooming in spring?

Soil water holds very little food for plants: the roots must take in enormous quantities of water: What becomes of some of this water?

Is the water which evaporates from the soil of any direct use to the plant?

The plant needs water,—it sweats it out: How shall we manage so that the plant can have all the water it needs?

Write down all the *substances* (or materials) you know which the plant must have in order to live and grow.

Which one of these does nature supply in sufficient abundance, without any thought on your part?

What ones can you help nature to supply?

Name all the congenial *conditions* (or agencies) which the plant must have in order to be comfortable and to grow.

What ones of these can you help nature to supply or maintain?

Name..

Post Office ....

INDEX OF CUTS AND PLATES.

GENERAL INDEX.